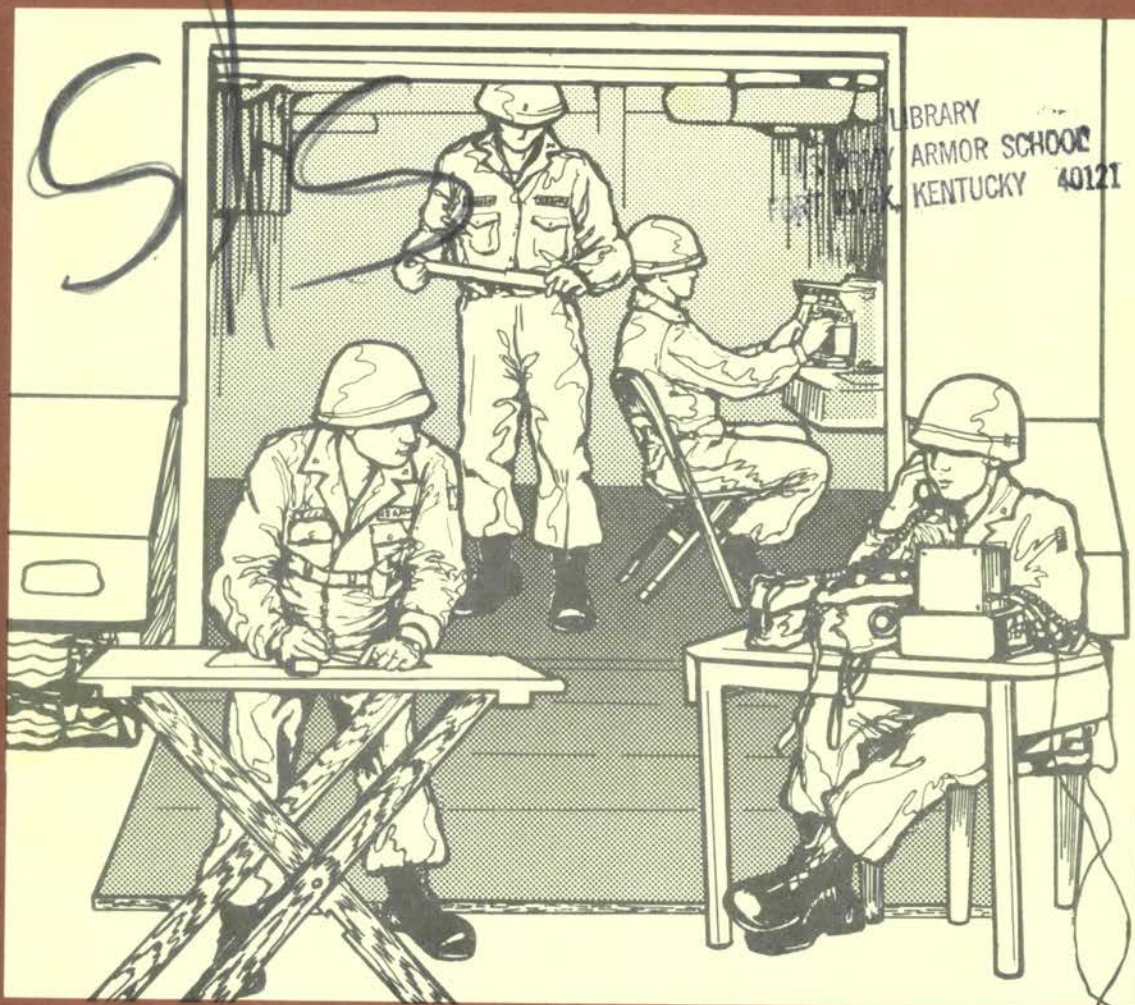


FM 6-40

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# FIELD ARTILLERY CANNON GUNNERY

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## FIELD ARTILLERY CANNON GUNNERY

1. Effective upon receipt. This change updates FM 6-40, 1 December 1978, with change 1, 3 April 1981. Changed material is indicated by a star (★) preceding the material.
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| i through iii     | j through iii     | 8-27 through 8-32       | 8-27 through 8-32       |
| 1-1 through 1-6   | 1-1 through 1-6   | 9-3 through 9-8         | 9-3 through 9-8         |
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| 8-23 and 8-24     | 8-23 and 8-24     | Index-1 through Index-3 | Index-1 through Index-4 |

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4. The words "he," "him," "his," and "men," when used in this publication, represent both the masculine and feminine genders, unless otherwise specifically stated.

**CHANGE 1, FM 6-40**

**3 APRIL 1981**

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# CHAPTER 1

# INTRODUCTION

## Section I. GENERAL

### 1-1. Purpose

The purpose of this manual is to provide a document that eliminates the need for multiple gunnery reference documents and explains:

*a.* Fire direction procedures used by manual/FADAC (field artillery digital automatic computer) equipped field artillery cannon units in combat.

*b.* Fire direction training conducted in peacetime to meet combat requirements.

### 1-2. Scope

*a.* This manual encompasses all aspects of field artillery cannon gunnery. The material presented herein applies to both nuclear and nonnuclear warfare. Hereafter, when the term "artillery" is used, it relates to field artillery unless otherwise stated.

*b.* Integrated manual/FADAC fire direction procedures are discussed only in terms of FADAC employment considerations and capabilities. To determine detailed FADAC operator procedures, consult the FADAC User's Manual.

★ *c.* Chronograph M90, laser rangefinder, rocket-assisted projectiles (RAP), hand-held calculator, and FASCAM (family of scatterable mines) procedures are incorporated into this text. Future changes to

FM 6-40 will be programed to support the development and operational tests of other field artillery systems (e.g., cannon-launched guided projectile (Copperhead)).

*d.* This manual does not address fire direction procedures under the tactical fire direction/battery computer system (TACFIRE/ BCS).

### 1-3. Target Audience

*a.* Trainers and supervisors of battery fire direction center (FDC) personnel.

*b.* Battalion operations/FDC personnel.

### 1-4. Changes or Corrections

Users of this manual are encouraged to submit recommended changes or comments to improve this manual. Comments should specify page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded to Commandant, US Army Field Artillery School, ATTN: ATSF-TD-TL, Fort Sill, Oklahoma 73503.

### 1-5. References

See appendix J for list of references.

## Section II. GUNNERY COMPONENTS

### 1-6. The Gunnery Problem

Field artillery cannons can engage targets at great ranges. Normally, they are emplaced in defilade to conceal them from the enemy and to protect them from enemy direct fire weapons. This placement usually precludes sighting the weapons directly at the target (direct fire). To attack a target, cannons must employ indirect fires. The gunnery problem is to determine aiming and ammunition data that insures timely, accurate, effective indirect fire. To solve the gunnery problem, we must:

- Know the location of the gun and determine the location of the target.
- Determine chart data (azimuth, range, and vertical interval).
- Convert chart data to firing data (fuze setting, deflection, and quadrant).

d. Apply the firing data to the gun and ammunition.

The solution to the problem provides weapon and ammunition settings that cause a projectile to burst on or at a predetermined height above the target.

### ★ 1-7. The Field Artillery Gunnery Team

The field artillery gunnery problem is solved through the coordinated efforts of the field artillery gunnery team (fig 1-1). The gunnery team consists of the observer, the fire direction center, and the firing battery linked by an adequate communication system. Field artillery doctrine requires team members to operate with a sense of urgency and continually strive to reduce the time required to execute an effective fire mission.

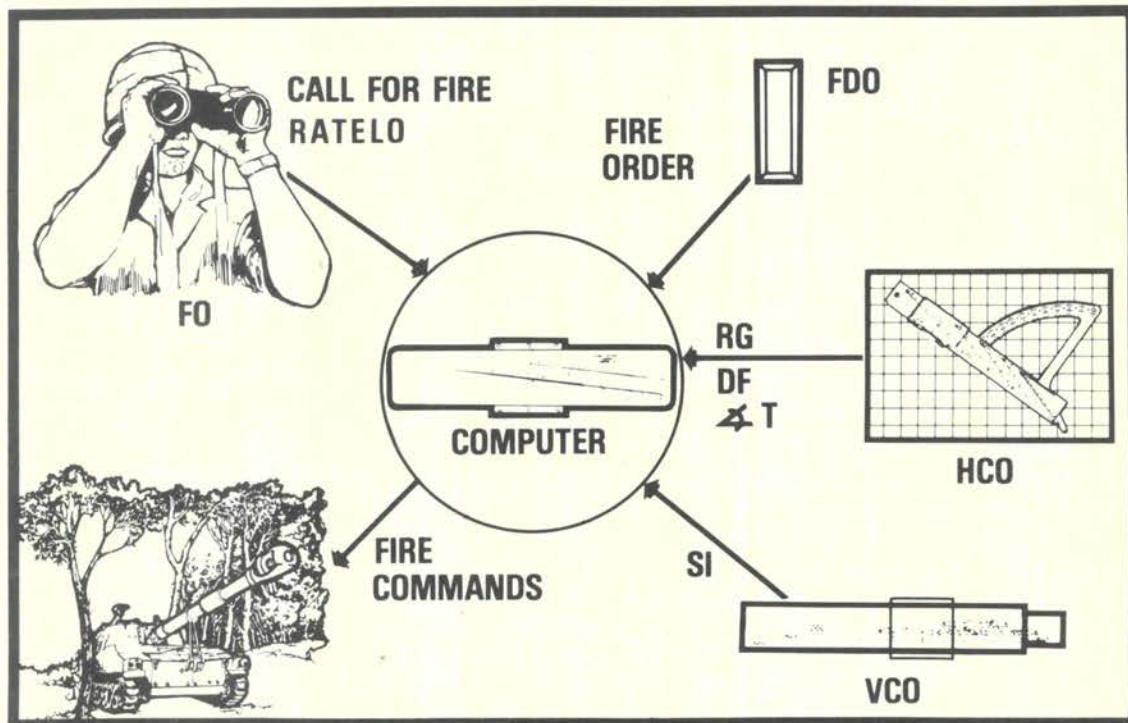


Figure 1-1. The field artillery gunnery team.



*a. Observer.* The observer serves as the eyes of all indirect fire systems. Personnel assigned to a fire support team (FIST) function as observers. The FIST chief functions as an observer and as the fire support coordinator (FSCoord) for the maneuver company commander. An observer detects and locates suitable indirect fire targets within his zone of observation. To attack a target, the observer transmits a request for fire and adjusts the fires onto the target when necessary. An observer provides surveillance data of his own fires and any other fires delivered in his zone of observation. See FM 6-20, *Fire Support in Combined Arms Operations*, for detailed duties of the FIST chief as a fire support coordinator. Observed fire procedures are in FM 6-30, *The Field Artillery Observer*.

*b. Fire Direction Center.* The fire direction center serves as the brain of the artillery system. The FDC receives the call for fire from the observer, plots the target location on

the firing charts (or enters target data into FADAC), determines chart and firing data, and converts it to fire commands. The FDC transmits the fire commands to the sections designated to fire the mission. Because of the great distance between units on the battlefield and requirements for improved responsiveness, technical fire direction normally is conducted by the battery FDC. The battalion FDC provides tactical fire direction, monitors all fire nets, and provides technical fire direction assistance to battery FDCs (e.g., fire plan firing data, fire direction backup, GFT (graphical firing table) setting transfer).

*c. Firing Battery.* The firing battery serves as the brawn of the artillery system. The firing battery consists of the firing battery headquarters and four or six howitzer or gun sections. The normal function of the cannon section is to deliver fires as directed by the FDC. Firing battery procedures are in FM 6-50, *The Field Artillery Cannon Battery*.

## Section III. FIELD ARTILLERY EFFECTIVENESS AND SURVIVABILITY

### 1-8. Field Artillery Effectiveness

*a. System Responsiveness.* In addition to gunnery, the field artillery (FA) system consists of target acquisition, weapons and munitions, and command and control. To be an effective force in the next battle, the field artillery must be responsive to the needs for our maneuver forces. To be responsive, we must streamline our procedures to minimize the timelag between target acquisition and rounds on the target. Unnecessary delay can result in our missing the intended target or placing fires on our advancing forces. Responsiveness can be achieved if we accomplish the following:

- (1) Place artillery requirements ahead.
- (2) Streamline the call for fire.

(3) Conduct technical fire direction at the battery level.

(4) Establish SOP fire order and fire command standards.

(5) Compute initial data by the fastest means available.

(6) Streamline firing battery procedures (see FM 6-50).

(7) Limit radio transmission on fire nets to time-sensitive, mission-essential traffic only.

*b. Effect on Target.* The ability of the field artillery system to place effective fires on a target will depend in part on the method of fire and type of ammunition selected to attack the target. Maximum effect can be achieved through surprise and mass fires.

(1) *Surprise*. Accurate surprise fire inflicts the greatest number of casualties. We must strive for first-round fire for effect or make a one-round adjustment if adjustment is necessary. Figure 1-2 compares effect achieved to length of adjustment.

★ (2) *Mass fires*. Massing all available artillery fires normally enables us to inflict maximum effect on a target with a minimum expenditure of ammunition in addition to reducing our vulnerability to enemy target acquisition devices. Failure to mass fires will provide the enemy time to react and seek protection. Figure 1-3 compares mass fire and successive volley ammunition expenditures to get equivalent effect. Time on targets (TOT) are more effective against soft targets than AT MY COMMAND and WHEN READY fire missions because they minimize the timelag between volley impacts. TOTs insure maximum effect when attacking targets that can change their posture category easily (e.g., a "soft" target—personnel in the open—can easily become a

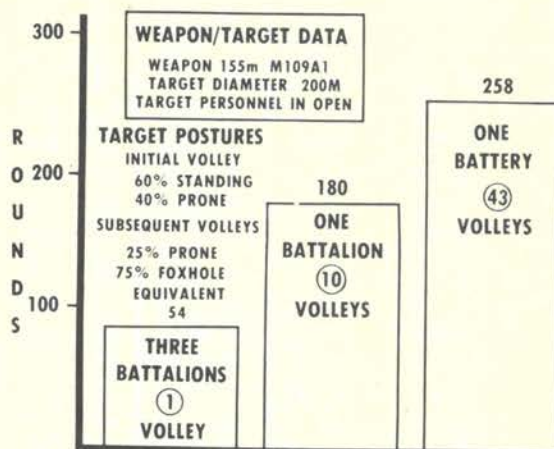


Figure 1-3. Number of rounds required for equivalent effect.

"hard" target—personnel with overhead cover). TOTs and AT MY COMMAND fire missions do not provide increased effectiveness against hard targets because volume of fire is more critical than round impact timing. WHEN READY fire missions

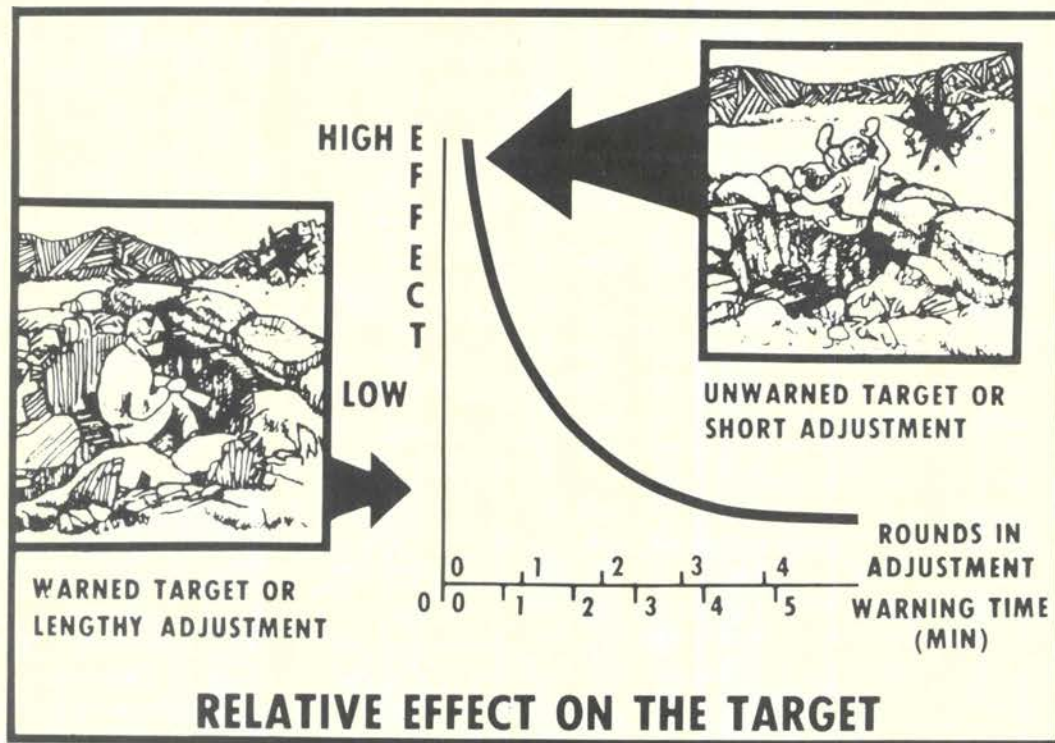


Figure 1-2. Effectiveness compared to length of adjustment.



provide a suitable method of fire for delivering required volumes of fire against hard targets. Chapter 2 discusses these missions in detail.

- ★ (3) *Proper munitions.* When attacking a target, the shell/fuze combination selected must be capable of producing desired results against the most vulnerable part of the target (e.g., guncrew versus the gun). Failure to select proper shell/fuze combinations will result in an excessive expenditure of critical ammunition supplies or a reduction in target effect. Figure 1-4 compares ammunition expenditures and relative effects. For additional information, see FM 6-141-1, *Field Artillery Target Analysis and Weapons Employment: Nonnuclear*, and (C) FM 6-141-2, *Field Artillery Target Analysis and Weapons Employment: Nonnuclear* (U).

### 1-9. Field Artillery Survivability

To shoot at all targets that appear on the battlefield or to register frequently makes our

artillery assets extremely susceptible to detection by enemy target acquisition devices. If our artillery units are located by threat forces, we can expect them to expend a large amount of ammunition to neutralize or destroy our positions. Commanders must constantly seek ways to improve FA support while avoiding detection or deceiving and confusing the enemy. Commander's guidance is essential for survival because that guidance establishes rules for target attack, charge selection, registrations, and split battery operations.

a. *Target Attack.* Surprise, massed low-angle fires significantly reduce the vulnerability of the firing unit to detection devices. These fires flood the enemy radar and sound systems for a very short period of time. This makes it extremely difficult for the operator to establish individual firing locations.

- ★ b. *Charge Selection.* Normally, the FDC selects the charge that will provide the

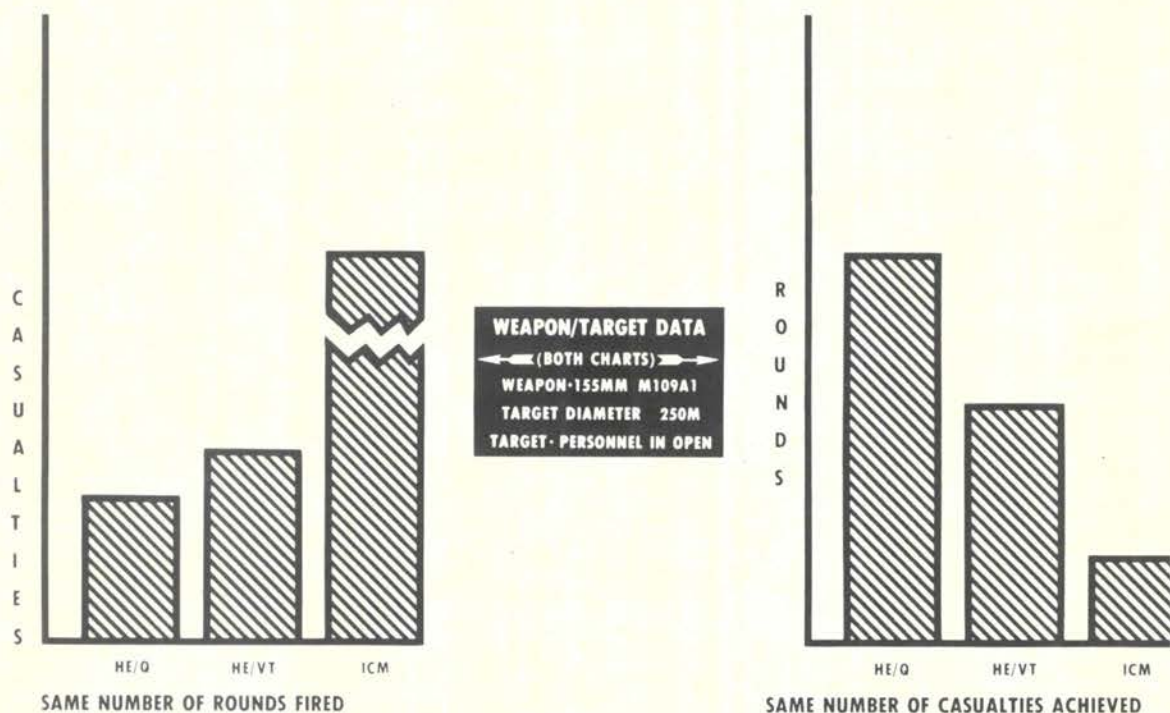


Figure 1-4. Ammunition expenditures and relative effects.

greatest accuracy at the target range. Using the charge selection table in the introduction of each tabular firing table (TFT) allows the FDC to select the optimum charge to use for accuracy and target ranges. In deciding the specific charge to fire, the FDC must consider all available information, including:

(1) The enemy electronic warfare (EW) and target acquisition capabilities existing in the target area (e.g., relative mix of sound and flash (SF) units versus counterbattery radars).

(2) Existing weather conditions at the time of firing and the effect on the enemy's use of his assets (e.g., clear and calm weather favors SF; windy and foggy conditions favor counterbattery radars).

(3) The type of fires requested, including consideration of time constraints (e.g., speed (suppressive effects) versus accuracy (neutralization of soft targets)).

(4) The type of terrain the firing element occupies and/or fires within (e.g., terrain masking, site to crest, min QE, dead space).

(5) Current/available enemy counter-artillery information (his target analysis priorities, plan of attack, etc.).

If analysis concludes that our howitzers are more susceptible to location by SF units than by radar, the lowest possible charge should be fired. If counterbattery radar is a significant threat, firing a higher charge would be more appropriate, as it would reduce the probability of detection by radar.

*c. Registrations.* From a vulnerability standpoint, met + VE is the best option for computing and firing predicted fires. If met is not available, we can use a number of alternate registration procedures to obtain corrections for predicted fire and reduce the possibility of detection.

## CHAPTER 2

# FIRE DIRECTION ORGANIZATION AND OPERATION

### Section I. FIRE DIRECTION PROCEDURES

#### 2-1. Definitions

a. Fire direction is the employment of firepower. It consists of both tactical and technical fire direction.

(1) FA tactical fire direction is the command of one or more units in the selection of targets to attack, the choice of the unit or units to fire, and the allocation of the most suitable ammunition for each mission.

(2) FA technical fire direction is the conversion of calls for fire from the observer into fire commands to the cannon sections.

b. The objectives of fire direction are to provide continuous, accurate, and responsive fire support under all conditions, to maintain flexibility to engage all types of targets over wide frontages, to mass the fires of all available units quickly, and to engage a number and variety of targets simultaneously.

c. The fire direction center is the element of the gunnery team with which the commander

directs artillery firepower. The accuracy, flexibility, and speed in the execution of fire missions depend on rapid and accurate determination of firing data; rapid and clear transmission of fire commands; integration of FADAC and manual equipment into an efficient, mutually supporting system; and efficient use of communications equipment.

#### 2-2. Relationship Between Battery and Battalion FDC

a. The wide frontages envisioned on the next battlefield, coupled with the need for decreased response time, demand a decentralized system of fire direction. Under this system, tactical fire direction is performed at the battalion FDC; technical fire direction is performed at the battery FDC.

b. The general duties of each FDC are outlined in table 2-1.

★ c. In a direct support battalion, most missions on targets of opportunity go directly from the observer to the appropriate battery

FDC. The battalion FDC and battalion fire support officer (FSO) monitor the call for fire (fig 2-1). The battalion FDC may take over control of the mission if the target warrants the massing of two or more batteries. The battalion FDC monitors the battery's message to observer (MTO) to insure that the battery has selected the appropriate ammunition and method of fire. The battalion FDC may change the battery's plan of attack. If the target requires battalion fires, the FIST member calls the mission directly to the battalion FDC (fig 2-2). The battalion FDC controls the time of firing of the batteries, but the batteries compute their own data. The battalion FSO may override the observer's request by substituting another fire support means. In a reinforcing (R), general support reinforcing (GSR), or general support (GS) role, fire missions usually go directly to the battalion FDC. The mission is then sent to the appropriate battery for computation of firing data.

d. The decentralized system of fire control is designed to provide maximum responsiveness; and, like other responsiveness techniques, the degree to which it is used depends upon several factors.

(1) *Battery FDC expertise.* A well-trained experienced FDC may handle technical fire direction easily. Personnel shortages, lack of experience, or lack of training may preclude the decentralized system.

(2) *Detailed guidance.* Unit SOPs (standing operating procedure) must contain detailed guidance concerning the attack of certain targets, types of missions (immediate suppression, immediate smoke, special missions), use of the fire order, etc. A detailed SOP, known by all concerned, eliminates the need for guidance from battalion FDC on most missions.

(3) *Proper supervision.* Battery FDCs supervised by an experienced fire direction officer (FDO) can handle the additional responsibility of decentralized operations better than those supervised by an inexperienced officer.

(4) *Tactical situation.* Direct support battalions should be more decentralized than reinforcing, general support reinforcing, or general support units. Offensive and covering force operations demand decentralization because of the rapid movement and flexible situation. Defensive situations may require more centralized control as more planned targets and more massed missions with other battalions may be fired.

e. Based on the above considerations, the battalion FDC may institute a variety of measures to increase or decrease control as necessary. Seven levels of control are outlined below.

1. The battalion FDC monitors missions and silence means consent.

★ Table 2-1. Duties of the Battalion and Battery FDCs

### BATTALION FDC

- Guidance to battery FDCs
- Control of mass fires
- Control of scheduled fires
- Data update
- Technical backup for battery FDC

### BATTERY FDC

- Computation of firing data
- Attack of targets of opportunity
- Attack of other targets as assigned



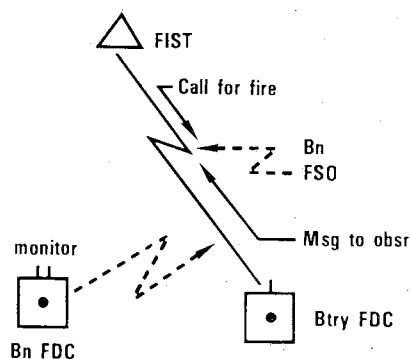


Figure 2-1. Battalion FDC and FSO monitor the call for fire.

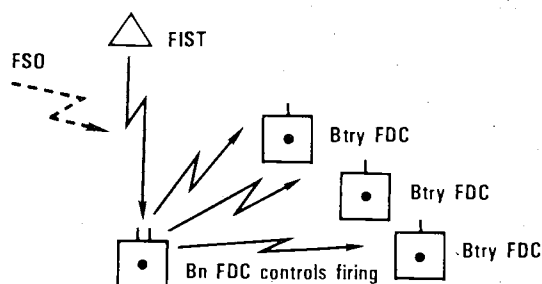


Figure 2-2. For battalion fires the mission is called directly to the FDC.

2. The battalion FDC informs the battery FDC that it monitored the call for fire; silence thereafter means consent.

3. The battalion FDC specifically tells the battery FDC that it agrees with the plan of attack.

4. The battery FDC consults with battalion FDC before determining the plan of attack.

5. The battalion FDC issues the plan of attack.

6. All missions are sent to battalion FDC where the plan of attack is determined.

7. The battalion FDC receives all missions and computes all data.

*Note.* Varying degrees of decentralization may be necessary with different battery FDCs. The

training program should be oriented toward the most decentralized and most responsive system.

## THE ULTIMATE GOAL IS DECENTRALIZATION.

### 2-3. Communications

a. In a direct support battalion, five FM radio nets are assigned: battalion command fire 1 (CF1), battalion command fire 2 (CF2), and three fire direction (FD) nets (F1, F2, F3). The battalion CF1 net is the primary net of the battalion. All battalion stations initially open and operate on this net unless otherwise directed by the battalion net control station (NCS). The battalion CF2 net provides flexibility by acting as an overflow or emergency net. Battalion CF1 or CF2 is initially used for all missions and other radio traffic to maintain security. Eventually, due to excessive traffic or compromise of battalion CF nets, the FD nets are employed (fig 2-3). The battalion FDC monitors all missions on all nets. Each FIST will talk to its associated battery on the appropriate FD net. Whenever possible, direct wire lines from battalion FDC to each battery FDC should be installed to increase security and facilitate communications. Fire support officers with maneuver battalions will use the battalion CF and the appropriate fire direction net to monitor all calls for fire. Fire support officers may intercede when targets plot outside boundaries or when other means of attack are more appropriate.

b. In battalions with reinforcing, general support reinforcing, or general support missions, two FM (frequency modulated) nets are usually assigned for fire direction: battalion command fire (battalion CF) and battalion fire direction (battalion FD). All FDCs will operate on both nets. Additionally, a reinforcing battalion FDC will use a third radio to monitor the reinforced battalion's CF net. (See FM 6-20, appendix I, for additional information on FSO communications.)

c. All calls for fire should be properly authenticated by the observer. There are

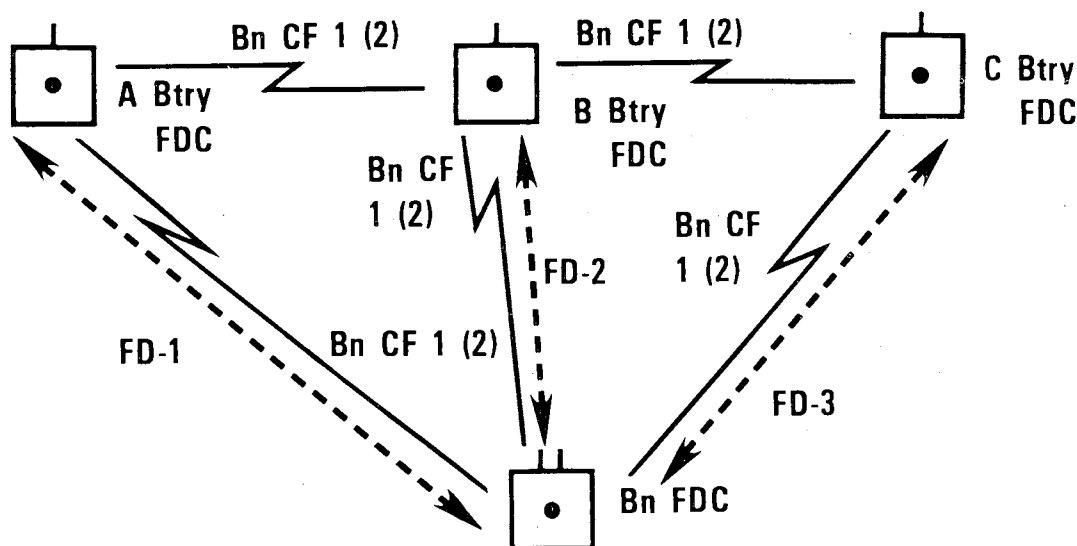


Figure 2-3. Employment of the FD nets.

instances when authentication may be deferred by the FDC. When the battery is in a high response posture (e.g., dedication), the FDC must exercise strong judgment before deferring authentication. Several factors should be considered.

(1) Is the station that is requesting fire an untrained observer? FIST observers are trained to expect a request for authentication and should know how to authenticate properly and rapidly. Untrained observers (e.g., maneuver personnel requesting fire) may not be as proficient in authentication and some delay may be expected.

(2) Have problems been experienced with enemy personnel using imitative deception, calling for fire, etc? The more

frequently this occurs, the more careful the FDC must be.

(3) How close is the reported target location to friendly elements? The closer the location to friendly positions, the more careful the FDC should be.

(4) Is it an adjust fire or fire for effect (FFE) mission? More care must be taken with FFE missions since these have the greatest potential for wasting ammunition and harming friendly troops. In a high response posture, challenge and authentication may have to be deferred until the first round(s) is on the way, but should be accomplished as soon as possible (prior to subsequent adjustment).

## Section II. DUTIES AND ORGANIZATION OF FDC PERSONNEL

The duties listed below are discussed in the context of a battery/battalion FDC under decentralized control. Certain duties are modified as the battalion FDC assumes tighter degrees of control.

### 2-4. Battery FDC Personnel

A battery FDC is composed of a fire direction officer, chief computer, computer, horizontal control operator, vertical control operator, and a radio-telephone operator.

*a. Fire Direction Officer:*

- (1) Runs the FDC and is responsible for fire direction operations.
- (2) Actively supervises all fire direction operations.
- (3) Establishes the fire order, the fire command standards, and SOP items.
- (4) Inspects the plot of each target, decides how to attack the target, and announces that decision in the fire order.
- (5) Insures that firing data is computed and sent to the guns correctly.
- (6) Supervises preparation and execution of preplanned fires.
- (7) Controls input of nonstandard conditions into FADAC.

*b. Chief Computer:*

- (1) Serves as the FDO's technical expert and the actual supervisor of the FDC.
- (2) Insures that all equipment is on hand and operational.
- (3) Supervises the computation of all data.
- (4) Insures that data is put into FADAC correctly.
- (5) Insures that all appropriate records are maintained.
- (6) Assists the FDO in his duties as necessary.

*c. Horizontal Control Operator (HCO):*

- (1) Operates and maintains the FADAC.
- (2) Enters known data as directed by the battery FDO.
- (3) Determines FADAC firing data.
- (4) Operates and maintains the FADAC generators.

*Note.* In an FDC where FADAC is not available, the HCO will construct and maintain the primary firing chart and determine chart data.

*d. Vertical Control Operator (VCO):*

- (1) Constructs and maintains the firing chart.

(2) Plots targets and announces and records their altitudes.

(3) Computes site and announces that site when requested by the computer.

(4) Maintains the battle map/overlays to include situation, fire capabilities, and dead space.

(5) Determines and announces angle T as necessary.

*Note.* In an FDC where FADAC is not available, the VCO's chart becomes the "check" chart. In addition to determining site, the VCO provides a check of the HCO's chart data.

★ *e. Computer:*

- (1) Combines the data provided by other personnel and produces fire commands.
- (2) Records the call for fire, fire order, firing data corrections, and other data as directed by the battery FDO.
- (3) Maintains all necessary records.
- (4) Computes firing data, converts firing data to fire commands, and transmits the fire commands to the battery in the proper sequence.
- (5) Computes and records calibrated muzzle velocities and battery comparative velocity errors (VE).
- (6) Computes registration, met + VE corrections, and other data as directed by the battery FDO.

*Note.* The hand-held calculator is a component of the computer set, FA, general, and is used by the computer.

*f. Radio-Telephone Operator (RATELO):*

- (1) Operates a radio or telephone in the FDC.
- (2) Determines and transmits the message to observer.
- (3) Encodes and decodes messages, target lists, and fire plans as necessary.
- (4) Insures proper authentication of appropriate messages and all fire missions.

## 2-5. Battalion FDC Personnel

A battalion FDC is composed of a fire direction officer, chief computer, assistant chief computer, three computers, a horizontal control operator, vertical control operator, and a radio-telephone operator.

### *a. Fire Direction Officer:*

(1) Is responsible for the overall organization and functioning of the battalion FDC.

(2) Coordinates with the battalion S3 to insure that all information regarding the tactical situation, unit mission, ammunition status, and commander's guidance on the method of engagement of targets and control of ammunition expenditures is known; and insures that all information is passed to battery FDOs.

(3) Insures that all communications are properly established.

(4) Coordinates with the chief computer concerning data input, chart verification, inferred GFT settings, average site or altitude, terrain gun position corrections (TGPC) sectors, and any other special instructions.

(5) Insures that the situation map is properly posted to include fire coordination measures and the current tactical situation.

(6) Inspects target locations and monitors messages to observer when a mission is received by a battery FDC and intercedes when necessary.

(7) Controls all battalion missions.

### *b. The Chief Computer:*

(1) Serves as the battalion FDO's technical expert—the actual supervisor of battalion FDC personnel.

(2) Insures that all battalion FDC equipment is operational and emplaced correctly.

(3) Insures that all data is coordinated throughout the battalion, that GFT settings are current, and that all data is computed correctly.

(4) Insures that the VCO's chart includes all pertinent known data.

### *c. Assistant Chief Computer:*

(1) Monitors all operations performed by the HCO.

(2) Insures that all data is properly entered in FADAC.

(3) Supervises maintenance and care of FADAC and the generators.

(4) Assumes the duties of the chief computer when he is absent.

### *d. Battery Computers:*

(1) Provide communications link with the battery FDCs.

(2) Monitor the appropriate fire direction net for their battery.

(3) Exchange information with the battery FDCs and pass battalion fire orders to the battery.

(4) Record all data pertinent to fire missions that are sent to their battery.

(5) Compute data for their battery when directed by the chief computer.

(6) Communicate with the observer when battalion missions are conducted using their fire direction net (F1, F2, or F3).

### *e. Horizontal Control Operator:*

(1) Serves as the FADAC operator.

(2) Enters known data as directed by the assistant chief computer.

(3) Computes data as appropriate.

(4) Maintains the FADAC and associated generators.

### *f. Vertical Control Operator:*

(1) Constructs and maintains the firing chart.

(2) Plots the initial target location when a mission is received.

(3) Determines data as directed by the chief computer.

*g. Radio-Telephone Operator:*

(1) Establishes and maintains communications on the battalion command fire net.

(2) Determines and transmits the message to observer when battalion missions are conducted on the battalion CF net.

(3) Encodes and decodes messages, target lists, and fire plans.

(4) Insures proper authentication of appropriate messages and all fire missions.

★ **2-6. Organization of Personnel**

The organization of FDC personnel and equipment is in appendix F.

## Section III. FIRE ORDER

### 2-7. Definition

When a call for fire is received in the battery or battalion FDC, the VCO immediately plots the target location on the firing chart. The FDO then examines the target plot on the firing chart and the situation map and conducts a brief analysis to determine how the target will be attacked. The result of this tactical fire direction process is announced in the fire order.

**FIRE ORDER: THE FDO'S DECISION ON HOW THE TARGET WILL BE ATTACKED, GIVEN IN A PRESCRIBED MANNER.**

### 2-8. FDO Considerations in Target Attack

In the FDC to which the mission is sent (btry or bn), the FDO must consider several factors in making his decision on how the target will be attacked.

*a. Location of Target.* The FDO must check the location relative to friendly forces, fire coordination measures, zones of fire, and registration transfer limits. The range will affect the choice of units to fire and charge selection. The terrain around the target may influence ammunition selection or type of trajectory. High intermediate crests may require selection of a lower charge.

*b. Nature of Target.* The size of the target will affect the number of units to fire, whether a special sheaf or spread is necessary, the selection of ammunition type, and the number of rounds in fire for effect. The type of target (troops, vehicles, hard, soft) will influence the ammunition type and amount, the priority to be placed on the mission, and whether surprise fire (e.g., time on target) is possible.

*c. Ammunition Available.* The FDO must consider the amount and type of ammunition available and the ammunition supply rate (ASR).

*d. Units Available.* The number of units



available will not only affect which units will be used but also the type of attack. Sweep and/or zone fire or other techniques may be necessary to cover large targets when sufficient units are not available.

*e. Commander's Guidance/SOP.* Restrictions on ammunition, operations orders, and SOPs may govern the selection of units and ammunition, target priority, and method of attack.

*f. Call for Fire.* The FDO must consider the observer's request carefully since he is the man who can see the target and talk directly to the maneuver commander. The observer's request should be honored when possible.

*g. Munitions Effects.* The Joint Munitions Effectiveness Manual (JMEM) or the Graphical Munitions Effectiveness Table (GMET) should be used as a guide to determine the type and amount of ammunition to be used against certain targets (see appendix C).

## 2-9. Elements of the Fire Order

*a.* The fire order is issued in a prescribed sequence. It consists of 10 elements: Unit to fire; adjusting element/method of fire of adjusting element; basis for corrections; distribution; projectile; ammunition lot and charge; fuze; number of rounds; range spread, lateral spread, sweep and zone; and time of opening fire.

★ (1) *Unit to fire.* The unit(s) to follow the mission and fire for effect. This will normally be a battery.

(2) *Adjusting element/method of fire of adjusting element.* The weapon(s) that will do the adjusting. Normally, this will be the base piece firing one round.

(3) *Basis for corrections.* How data will be determined. Normally, the *fastest method* will be designated allowing the FADAC to compete with the GFT fan on the initial round.

(4) *Distribution.* The pattern of bursts in the impact area. Normally, a parallel

sheaf will be fired; however, the FDO will announce the type of sheaf here (e.g., ★ **SPECIAL CORRECTIONS—CONVERGED SHEAF**). Terrain gun position correction sectors are also announced here.

(5) *Projectile.* The projectile to be fired in adjustment and fire for effect (see (8) below).

(6) *Ammunition lot and charge.* The ammunition lot and charge used in adjustment and fire for effect. If high angle is to be used, the FDO will say **HIGH ANGLE** in place of the charge (see (8) below).

★ (7) *Fuze.* The fuze to be used in adjustment (see (8) below).

| ELEMENT                                     | STANDARD       |
|---------------------------------------------|----------------|
| UNIT TO FIRE                                | BATTERY        |
| ADJ ELEMENT/MOF OF ADJ ELEMENT              | # 3 ①          |
| BASIS FOR CORRECTIONS                       | FASTEST METHOD |
| DISTRIBUTION                                | PARALLEL       |
| PROJECTILE                                  | HE             |
| AMMO LOT & CHG                              | RT/4           |
| FUZE                                        | Q              |
| NUMBER OF ROUNDS                            | ①              |
| RANGE SPREAD, LATERAL SPREAD, ZONE OR SWEEP | CENTER RG & DF |
| TIME OF OPENING FIRE                        | WHEN READY     |

Figure 2-4. Battery fire order standards.

★ (8) *Number of rounds.* The number of rounds to be fired in fire for effect by each weapon designated in (1) above. If the fire for effect projectile, lot, or fuze is different from that used in adjustment, it will be announced after the number of rounds. For example, **4 ROUNDS, SHELL ICM, LOT ZY, FUZE TIME IN EFFECT.**

(9) *Range spread, lateral spread, sweep and zone.* Techniques to cover large targets. Normally, the center range and deflection will be fired.

(10) *Time of opening fire.* When the guns may commence firing. They may fire **WHEN READY, AT MY COMMAND**, or a time on target may be designated.

b. When issuing the fire order, the FDO must address each element orally or by using the standard (fig 2-4).

## 2-10. Fire Order Standards

a. In most cases, a particular element of the fire order may not change from one mission to the next. Based on the tactical situation, type and amount of ammunition available, and commander's guidance, the FDO establishes a standard for each element. These standards should be displayed prominently in the FDC. When the FDO does not address an element in his fire order, the standard for that element will apply. The FDO need only announce what has changed from the standard.

### PROPER SELECTION OF FIRE ORDER STANDARDS REDUCES THE NEED FOR LENGTHY FIRE ORDERS.

Examples of established fire order standards are shown in tables 2-2 through 2-4.

b. The FDO must remember that the fire order must be *clear, concise, and in proper format*. The fire order format is designed to disseminate information clearly and rapidly with a minimum of discussion, but if a situation requires, necessary clarification should be provided. In other words, the FDO must "use" the system, not "be used" by it. It is impossible to provide a textbook solution for every conceivable situation, but a combination of technical knowledge and common sense should be sufficient to avoid confusion. It is better, if any possibility of confusion exists, to be redundant rather than too brief.

## 2-11. Use of the SOP

The use of a good SOP to clarify certain missions is essential. Immediate suppression, immediate smoke, illumination, and mixed shell missions (HE and WP, for

instance) can be handled more responsively when governed by SOP. For example, an FDO need only say **IMMEDIATE SUPPRESSION** to mean a platoon will fire two volleys of HE/VT.

### GOOD SOPs AND EXTENSIVE TRAINING CAN RESULT IN MORE STREAMLINED FIRE ORDERS.

## 2-12. Fire Orders at Battalion FDC

a. Under decentralized operations, the battery FDOs will establish their own fire order standards. (A degree of centralization may include the battalion FDO establishing the fire order standards.) Once the battery standards have been established, they should be reported to the battalion FDC. The battalion FDO should attempt to resolve differences in battery fire order standards to make them as similar as possible. By doing this, the battalion FDO will simplify the fire order he will issue for battalion missions. The standards are posted in the battalion FDC where they are visible to all personnel. An example of battalion standards is shown in figure 2-5.

| ELEMENT                                           | STANDARD          |
|---------------------------------------------------|-------------------|
| UNIT TO FIRE                                      | BTRY              |
| ADJ ELEMENT/MOF<br>OF ADJ ELEMENT                 | BP ①              |
| BASIS FOR<br>CORRECTIONS                          | FASTEST METHOD    |
| DISTRIBUTION                                      | PARALLEL          |
| PROJECTILE                                        | HE                |
| AMMO LOT & CHG                                    | A&B: RT/4 C: RT/5 |
| FUZE                                              | Q                 |
| NUMBER OF ROUNDS                                  | ①                 |
| RANGE SPREAD,<br>LATERAL SPREAD,<br>ZONE OR SWEEP | CENTER RG & DF    |
| TIME OF OPENING<br>FIRE                           | WHEN READY        |

Figure 2-5. Battalion fire order standards.

*Note.* Ammunition lot and charge may be different for each battery.

b. The battalion FDO's fire order is similar to the battery fire order except that it is modified slightly to alert the batteries as to the type mission and to send target location data.

(1) The battalion FDO will first issue a WARNING indicating the type mission (AF, FFE).

(2) For UNIT TO FIRE, the battalion FDO will designate Bn or A and C (batteries available) for fire for effect missions, or Bn, B indicating B battery will adjust and the battalion will fire in fire for effect.

(3) ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT is not addressed in the battalion fire order. Instead, after UNIT TO FIRE, the battalion FDO will indicate the target location and altitude if the batteries have not heard it. For instance, if the mission was sent on the battalion CF net, which all batteries monitor, the battalion FDO would not need to include target location. On the other hand, a battalion

mission sent on a fire direction net (F1, F2, or F3) would be heard only by the battery on that net.

(4) For TIME OF OPENING FIRE, the battalion FDO may designate **TIME ON TARGET, AT MY COMMAND (AMC)** or **WHEN READY** as discussed in d through g below.

c. Each computer at battalion FDC records the battalion FDO's fire order and transmits it to his battery FDC.

d. Massing the fires of more than one battery can be either fire for effect or adjusted, and may be fired either **TIME ON TARGET, AT MY COMMAND**, or **WHEN READY**. The most effective technique is FFE, TOT, which achieves the greatest surprise and generally produces the greatest number of casualties.

e. Control of FFE, mass missions on stationary targets can best be effected using TOT techniques. Accurate time coordination is essential to insure the simultaneous impact of all initial rounds, but lengthy countdowns are unnecessary.

Table 2-2. Sample Fire Order Standards

| ELEMENT                                     | SAMPLE TACTICAL SITUATION:<br>Maneuver units preparing to advance. FDO anticipates observers will be required to adjust fire on most targets; establishes the following fire order standards: | SAMPLE CALL FOR FIRE:<br>"H44, ADJUST FIRE, OVER-GRID 196432, OVER---COMPANY ASSEMBLY AREA, VT IN EFFECT, OVER."<br><br>FDO ACTIONS: Agrees with observer's call for fire; desires to fire two rounds in effect. Issues following fire order: |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNIT TO FIRE                                | BATTERY                                                                                                                                                                                       |                                                                                                                                                                                                                                               |
| ADJ ELEMENT/MOF OF ADJ ELEMENT              | # 3 ①                                                                                                                                                                                         |                                                                                                                                                                                                                                               |
| BASIS FOR CORRECTIONS                       | FASTEST METHOD                                                                                                                                                                                |                                                                                                                                                                                                                                               |
| DISTRIBUTION                                | PARALLEL SHEAF                                                                                                                                                                                |                                                                                                                                                                                                                                               |
| PROJECTILE                                  | HE                                                                                                                                                                                            |                                                                                                                                                                                                                                               |
| AMMO LOT & CHG                              | RT/4                                                                                                                                                                                          |                                                                                                                                                                                                                                               |
| FUZE                                        | Q                                                                                                                                                                                             |                                                                                                                                                                                                                                               |
| NUMBER OF ROUNDS                            | ①                                                                                                                                                                                             | ②. VT IN EFFECT                                                                                                                                                                                                                               |
| RANGE SPREAD, LATERAL SPREAD, ZONE OR SWEEP | CENTER RG & DF                                                                                                                                                                                |                                                                                                                                                                                                                                               |
| TIME OF OPENING FIRE                        | WHEN READY                                                                                                                                                                                    |                                                                                                                                                                                                                                               |

MESSAGE TO OBSERVER: "BRAVO, TWO ROUNDS, OVER."

Table 2-3. Sample Fire Order Standards

| ELEMENT                                        | SAMPLE TACTICAL SITUATION:<br>You are supporting covering force operations.<br>The tactical situation is changing rapidly. You are moving frequently. TGPC are being used. | SAMPLE CALL FOR FIRE:<br>M44, FFE, over, Grid 203348, over, PLT ZSU-23-4, ICM.<br>FDO ACTIONS:<br>Agrees with observer request, TOT is in primary TGPC sector, decides to fire 3 rounds, at my command. |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNIT TO FIRE                                   | BATTERY                                                                                                                                                                    |                                                                                                                                                                                                         |
| ADJ ELEMENT/MOF OF<br>ADJ ELEMENT              | # 3 ①                                                                                                                                                                      | FIRE FOR EFFECT                                                                                                                                                                                         |
| BASIS FOR CORRECTIONS                          | FASTEST METHOD                                                                                                                                                             |                                                                                                                                                                                                         |
| DISTRIBUTION                                   | PRIMARY SECTOR                                                                                                                                                             |                                                                                                                                                                                                         |
| PROJECTILE                                     | HE                                                                                                                                                                         | ICM                                                                                                                                                                                                     |
| AMMO LOT & CHG                                 | RT/6                                                                                                                                                                       | WT                                                                                                                                                                                                      |
| FUZE                                           | Q                                                                                                                                                                          | Ti                                                                                                                                                                                                      |
| NUMBER OF ROUNDS                               | ①                                                                                                                                                                          | ③                                                                                                                                                                                                       |
| RANGE SPREAD, LATERAL<br>SPREAD, ZONE OR SWEEP | CENTER RG & DF                                                                                                                                                             |                                                                                                                                                                                                         |
| TIME OF OPENING FIRE                           | WHEN READY                                                                                                                                                                 | AT MY COMMAND                                                                                                                                                                                           |

MESSAGE TO OBSR: "BRAVO, THREE ROUNDS, OVER;"

Table 2-4. Sample Fire Order Standards

| ELEMENT                                        | SAMPLE TACTICAL SITUATION:<br>Maneuver units in defensive posture. Targets in fire plan are plotted and corrections have been determined. Variety of targets expected. FDO anticipates he can FFE most of the time; establishes the following standards: | SAMPLE CALL FOR FIRE:<br>H44, FFE, over, Grid 187236, over, PLT in Open, ICM, over.<br>FDO ACTIONS:<br>Desires to fire ⑤ HE/VT<br>(No ICM available) |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNIT TO FIRE                                   | BATTERY                                                                                                                                                                                                                                                  |                                                                                                                                                      |
| ADJ ELEMENT/MOF OF<br>ADJ ELEMENT              | FIRE FOR EFFECT                                                                                                                                                                                                                                          |                                                                                                                                                      |
| BASIS FOR CORRECTIONS                          | FASTEST METHOD                                                                                                                                                                                                                                           |                                                                                                                                                      |
| DISTRIBUTION                                   | PRIMARY SECTOR                                                                                                                                                                                                                                           |                                                                                                                                                      |
| PROJECTILE                                     | HE                                                                                                                                                                                                                                                       |                                                                                                                                                      |
| AMMO LOT & CHG                                 | SW/5                                                                                                                                                                                                                                                     |                                                                                                                                                      |
| FUZE                                           | VT                                                                                                                                                                                                                                                       |                                                                                                                                                      |
| NUMBER OF ROUNDS                               | ①                                                                                                                                                                                                                                                        | ⑤                                                                                                                                                    |
| RANGE SPREAD, LATERAL<br>SPREAD, ZONE OR SWEEP | CENTER RG & DF                                                                                                                                                                                                                                           |                                                                                                                                                      |
| TIME OF OPENING FIRE                           | AT MY COMMAND                                                                                                                                                                                                                                            |                                                                                                                                                      |

MESSAGE TO OBSERVER: "Bravo, VT, Five Rounds, Over"

(1) The TOT may be announced as a specific time (e.g., TOT 0915). The battalion FDO would cause a time check to be announced (e.g., time is now 0908) in order to synchronize the batteries designated to fire. Each battery would control its own firing.

(2) Another technique to execute a TOT is to specify the amount of time before it is to occur (e.g., TOT 5 minutes from . . . NOW). Each battery FDC would start its stopwatch at . . . "NOW." From that moment, each battery FDC would control its own firing.

(3) A third (preferred) technique for execution of a TOT is to determine the time to begin a short countdown based on the longest time of flight of the designated batteries to fire. After each battery reports ready and time of flight, the battalion FDO adds 10-15 seconds to the longest time of flight, expressing his answer to the nearest 10 seconds. He then announces, **TIME ON TARGET . . . (so many) SECONDS FROM . . . NOW.** Each battery FDC would start its stopwatch at . . . "NOW." From that moment, each battery FDC would control its own firing.

★ *f.* Control of an FFE, mass mission on moving targets or targets of a fleeting nature is best effected using **AT MY COMMAND** or **WHEN READY**, where time consumed during a TOT countdown may result in the rounds missing the target.

(1) **AT MY COMMAND.** All units will fire simultaneously. The battalion FDO will select this technique if he is willing to accept some loss of surprise caused by varying times of flight in order to get the rounds on the target quickly. This technique is particularly effective when unit times of flight are similar.

(2) **WHEN READY.** Unless otherwise specified, each battery will fire when ready.

This technique is used more often with adjust fire missions (particularly those with lengthy adjustment phases) than with fire for effect missions. (When surprise has been lost, the difference in reaction times and times of flight between units is less significant.) In fire for effect missions, this technique would normally be used only if time is critical or the target has the capability to displace rapidly.

*g.* Control of the FFE phase of an adjust fire mass mission can be effected by the same means as FFE mass missions.

(1) **TIME ON TARGET.** If the observer is able to enter FFE with a large correction and he judges the target has not been warned, a TOT as discussed in paragraph *e* above may be used to control time of firing in effect. If the battalion FDO decides a TOT is unsuitable (e.g., loss of time outweighs simultaneous impacting of all initial FFE rounds), he will direct use of **AT MY COMMAND** or **WHEN READY**. It is rare that a target would not be warned during adjustment. Therefore, TOT to control time of firing in effect after adjustment is not normally used.

(2) **AT MY COMMAND.** The considerations for the selection of this technique are the same as discussed in paragraph *f*(1) above. In addition, it is useful if the observer is able to enter FFE with a large correction.

(3) **WHEN READY.** In most adjust fire mass missions, no control of time of firing in effect will be used. Since most targets would be warned during adjustment, the battalion FDO would allow batteries to fire when ready.

*h.* Examples of battalion fire orders are contained in section VI.

## Section IV. FIRE COMMANDS

### 2-13. Definition

Fire commands are used by the FDC to give the cannon sections all information needed to start, conduct, and cease firing. The initial fire commands include all elements necessary for orienting, loading, and firing. Subsequent fire commands include only the elements that are changed (except quadrant elevation, which is always announced because it gives permission to fire). As in the fire order, fire commands are always announced in a standard sequence to save time and eliminate errors.

### 2-14. Elements of Fire Commands

The elements of the fire commands are listed (fig 2-6) and briefly discussed below. For a detailed discussion of fire commands, refer to FM 6-50.

*a. Warning Order.* A warning order of **FIRE MISSION** is always announced to alert the firing battery to the mission.

*b. Pieces to Follow/Pieces to Fire/Method of Fire.* "Pieces to follow" indicates those elements that will follow the mission and fire when called upon. **BATTERY ADJUST**

| SEQUENCE OF ELEMENTS                                                                                                                                                                                                                      | WHEN ANNOUNCED       |                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------------|
|                                                                                                                                                                                                                                           | Initial Fire Command | Subsequent Fire Command |
| 1. Warning Order                                                                                                                                                                                                                          | Always               | Never                   |
| 2. Pieces to Follow/Pieces to Fire*/ Method of Fire *                                                                                                                                                                                     | Always               | When Applicable         |
| * * 3. Special Instructions:<br><br>Do Not Load<br>At My Command/By Piece At My Command<br>High Angle<br>Use Gunner's Quadrant<br>Azimuth<br>Primary Sector/Left Sector/Right Sector<br>Cancel Terrain Corrections<br>Special Corrections | When Applicable      | When Applicable         |
| * 4. Projectile                                                                                                                                                                                                                           | When Not Standard    | When Changed            |
| * 5. Ammunition Lot                                                                                                                                                                                                                       | When Not Standard    | When Changed            |
| 6. Charge                                                                                                                                                                                                                                 | Always               | When Changed            |
| * 7. Fuze/Fuze Setting                                                                                                                                                                                                                    | When Not Standard    | When Changed            |
| 8. Direction (announced as DEFLECTION _____)                                                                                                                                                                                              | Always               | When Changed            |
| 9. Quadrant Elevation                                                                                                                                                                                                                     | Always               | Always                  |
| 10. Method of Fire For Effect                                                                                                                                                                                                             | When Applicable      | When Changed            |

Figure 2-6. Elements of the fire command.

\*Element may be standardized and not announced in initial fire commands.

\*\*When TGPC (see chapter 8) are being used, unit SOP will determine what corrections will be applied. Normally, the corrections for the primary sector will be carried on the weapons unless the command "Left Sector," "Right Sector," or "Cancel Terrain Corrections" is announced by the FDC.



indicates the battery will follow the mission and prepare to fire when commanded. "Pieces to fire/method of fire" indicates the weapon(s) that will fire the initial data announced and how many rounds to fire. Method of fire will also include sweep and/or zone instructions. **NUMBER 3 (or BP) ONE ROUND** indicates that only that piece will fire one round. **BATTERY FIVE ROUNDS** indicates the entire battery will fire five volleys.

*c. Special Instructions.* Special instructions are used whenever actions are required that are different from normal. They include:

(1) **DO NOT LOAD**—a restrictive command that prohibits loading and firing. This is used when it is anticipated that significant time will elapse between loading and firing. The nonadjusting batteries in a battalion mission would not load until fire for effect. To cancel this, announce **CANCEL DO NOT LOAD, QUADRANT----**.

(2) **AT MY COMMAND**—a restrictive command that prohibits the battery from firing until directed to do so by the FDC. This would be used during TOT missions to insure that all rounds land simultaneously. The guns will fire at the command **FIRE. AT MY COMMAND** remains in effect until the command **CANCEL AT MY COMMAND** is given.

(3) **HIGH ANGLE**—announced to alert the crew that the mission is high angle.

(4) **USE GUNNER'S QUADRANT**—announced whenever FDC desires that the gunner's quadrant be used.

(5) **AZIMUTH**—announced to alert the guns to a large shift in direction of fire.

(6) **SPECIAL CORRECTIONS**—announced whenever a separate time, deflection, and/or quadrant will be sent to one or more gun sections.

(7) **LEFT (RIGHT) SECTOR**—announced when terrain gun position

corrections for the left (right) sector are to be applied.

(8) **CANCEL TERRAIN CORRECTIONS**—announced to direct the gun sections to reset their gunner's aid counters to zero.

*d. Projectile.* This is the type projectile that is to be prepared and loaded.

*e. Ammunition Lot.* This is the ammunition lot to be used. Lot numbers should be coded for simplicity. Separate-loading ammunition would have two designations—one for the projectile and one for the propellant. Semifixed ammunition would have only one.

*f. Charge.* Charge indicates the amount of propellant to be used and is *always* announced in initial fire commands to reduce the chances of a charge error being fired.

*g. Fuze/Fuze Setting.* This indicates the type of fuze/fuze setting to be used.

*h. Direction.* Direction of fire is always announced as a four-digit deflection.

*i. Quadrant Elevation.* The quadrant elevation is announced in initial and all subsequent fire commands. The command **QUADRANT (so much)** is permission for the chief of section to load and fire the round unless otherwise restricted by special instructions.

*j. Method of Fire for Effect.* The method of fire for effect indicates the number of rounds and type of ammunition to be used in effect.

*k. Special Methods of Fire.* Special methods of fire include **CONTINUOUS FIRE** and **FIRE AT WILL**.

## 2-15. Fire Command Standards

Once the fire order standards are established, standard fire commands are established. Only certain elements of the fire commands may be standardized. Those elements are then announced only when they are different from the standard.

**ONLY THESE ELEMENTS  
MAY BE STANDARDIZED**  
**Pieces to Fire/Method of Fire**  
**Projectile**  
**Ammunition Lot**  
**Fuze/Fuze Setting**

**2-16. Use of the SOP**

Unit SOP may allow loading when deflection is announced. This is discouraged for self-propelled weapons as the noise of the rammer may preclude the announced quadrant from being heard. More frequently, unit SOP may require "automatic reload." In this instance, a round (HE/Q) is loaded by the adjusting piece immediately after firing. This will reduce the time taken by the adjusting piece during adjustment.

**2-17. Subsequent Commands**

Any fire command element that changes must be announced. Subsequent commands are announced in the same order as the initial fire commands.

**2-18. Additional Fire Commands and Reports**

*a. Check Firing.* The command **CHECK FIRING** can be given by anyone and causes firing to cease immediately. (This command will be used when all data has been sent to the guns and an item must be changed.)

★ *b. Cease Loading.* The command **CEASE LOADING** allows the firing battery to fire rounds that are loaded, but no additional rounds may be loaded.

*c. End of Mission.* The command **END OF MISSION** means that the fire mission is terminated. The guns should return to the azimuth of lay (or priority target data) and apply the terrain corrections designated as standard if applicable.

*d. Reports.* The section chief reports to the FDC all actions that affect the firing of his weapons in support of the battery mission.

During firing, the following specific reports are made:

(1) **SHOT NUMBER** (so and so) after each round has been fired.

(2) **ROUNDS COMPLETE NUMBER** (so and so) when the final round has been fired in effect.

(3) **MISFIRE NUMBER** (so and so) when there has been a misfire.

(4) **NUMBER OF ROUNDS EXPENDED** by type and lot number when requested by FDC.

(5) **ERRORS** if any round has been fired with improper data. The section chief will report to the FDC the actual data fired in error; e.g., **NUMBER 2 FIRED DEFLECTION** (so much).

★ *e. Planned Targets.* The battery may be assigned planned targets for which current firing data must be maintained. The FDC may designate targets as priority targets for the battery or for each platoon, and each weapon will be laid on its assigned priority target. In such cases, unit SOP usually designates a command or prearranged signal to fire on the priority target, bypassing the usual sequence of fire commands. Assume target 43 has been planned. On the command **RIGHT, SUPPRESS 43**, the right platoon engages target 43 with the previously arranged method of fire. In defensive operations, the command **FIRE THE FPF** causes the firing battery to fire the final protective fires on which they are laid.

**2-19. Repetition and Correction of Fire Commands**

*a.* One section of the firing battery should be designated to read back all fire commands to insure that the howitzer sections have received the fire commands correctly. When a command has not been heard or understood, the request for repetition is stated as a question; e.g., **DEFLECTION NUMBER 3?** When the FDC replies, the repetition of commands is always preceded by **THE**

**COMMAND WAS; e.g., THE COMMAND WAS DEFLECTION 2768.**

b. If an incorrect command has been given but the command **QUADRANT** has not been announced, the FDC commands **CORRECTION** followed by the correct command and all subsequent elements. If **QUADRANT** has been announced, the FDC commands **CHECK FIRING**. Then **CANCEL CHECK FIRING** is announced followed by the corrected element and all subsequent elements.

### ★ 2-20. Fire Commands for DPICM and ICM

The recommended method of announcing the type of projectile to fire is to announce the general projectile type as **SHELL**\_\_\_\_, **LOT**\_\_\_\_. The lot code identifies both the model of the projectile to be fired and the manufacturer's lot. Table 2-5 shows the recommended commands for projectile identification in fire order and initial fire commands.

| Projectile        | Fire Order and Initial Fire Commands |                         |                                     | Subsequent Fire Commands |
|-------------------|--------------------------------------|-------------------------|-------------------------------------|--------------------------|
|                   | SH _____                             | LOT _____<br>(See note) | _____ IN EFF<br>(FFE Warning Order) | MF, SH,<br>CHG, FZ       |
| M449              | ICM                                  | AY                      | *ICM, LOT _____                     | *ICM, LOT _____          |
| M449E1            | ICM                                  | BY                      | *ICM, LOT _____                     | *ICM, LOT _____          |
| M449A1            | ICM                                  | CY                      | *ICM, LOT _____                     | *ICM, LOT _____          |
| M483A1 (SR Mode)  | DP-SR                                | MY                      | NA                                  | NA                       |
| M483A1 (FFE Mode) | DP                                   | MY                      | DP Mode in Effect                   | DP Mode in Effect        |
| M692              | ADAM-L                               | PY                      | **ADAM-L, LOT _____                 | **ADAM-L, LOT _____      |
| M731              | ADAM-S                               | XY                      | **ADAM-S, LOT _____                 | **ADAM-S, LOT _____      |
| M718              | RAAM-L                               | TY                      | **RAAM-L, LOT _____                 | **RAAM-L, LOT _____      |
| M741              | RAAM-S                               | RY                      | **RAAM-S, LOT _____                 | **RAAM-S, LOT _____      |

\*Adjustment with HE; if adjustment was with FFE round, no entry.

\*\*Adjustment with DP-SR only.

Note. Lot codes are assigned by FDO/XO.

★ Table 2-5. Commands for Projectile Identification.

## Section V. BATTERY MISSION PROCESSING

### ★ 2-21. FDC Procedures

In the battery FDC all actions must be oriented toward timely and accurate computation and transmission of fire commands. All actions must provide the best possible flow of information between FDC personnel. The battery FDC must be trained to accomplish the responsive and accurate determination of firing data. To insure responsiveness, FDC personnel must be trained as a team to accomplish many operations simultaneously.

*a. Deflection Corrections.* For immediate suppression missions on targets of opportunity, the computer applies the registration (or inferred) total deflection correction, regardless of the amount of drift change. For an adjust fire mission when more time is available, the drift change is considered and applied to the GFT deflection correction. Regardless of the amount of deflection correction applied, replot procedures are as outlined in chapter 10.

*b. Transfer From Manual to FADAC Computations.* FADAC is the primary means of computing firing data and should be used whenever possible. It is the most accurate means available and, in most cases, the fastest. However, data for the initial adjusting round of a mission often can be computed faster by manual methods. Thus, in many cases, the initial data fired will be computed manually while subsequent rounds will be fired using FADAC data. When this occurs, the FDO must evaluate the effect of any differences between the initial manual data and the FADAC data and decide which method will be used to continue the mission.

(1) If a FADAC-derived GFT setting is being used on the graphical equipment and FADAC/manual chart checks have been conducted, there should be no significant differences between the two sets of data (a

difference of 3 mils or less in deflection or QE is not considered significant). If the difference is excessive, the mission should be continued manually (otherwise, the observer may not get the correction he requested), and the FDO should announce **USE GFT**. If the difference is acceptable, the FDO announces **USE FADAC** and all subsequent rounds are fired with FADAC data. This decision must be made quickly and is especially critical if the first subsequent correction includes **FIRE FOR EFFECT**.

(2) This procedure is used for any time-sensitive mission, including immediate suppression (since the observer may decide to continue the mission and neutralize the target). The FDC must use comparable input data for both manual and FADAC computations; e.g., if average site is used manually, average altitude should be used in FADAC.

*c. Site.* On any battery mission that is adjusted, average site usually will be sufficiently accurate. On a mass or first-round fire-for-effect mission, actual site will be computed. When immediate suppression (or any other emergency mission) is requested, site may be ignored if no average site is available. Otherwise, average site is included. Replot procedures in chapter 10 apply.

*d. Average Site/Altitude.* When average site (altitude) is used in computation of firing data, time will be saved only if average values have been determined before they are needed. Accuracy of the average values is improved as time allows, in three phases.

(1) *Phase I-estimation by map inspection.* This method results in determination of only one or two values of site (average altitude for FADAC) for an entire zone of fire. Site is computed by examining the map and selecting one or two values of altitude (which are representative of the

entire zone) and computing site for each. This method will cause significant error if the terrain is very hilly or if there are large differences in range.

(2) *Phase II-plotting contour intervals.* The VCO colors his map for specified contour interval, normally 30 meters (100 ft). The altitude reported to the FADAC operator is the average altitude for the colored contour interval in which the target is plotted. Average site for each contour sector is precomputed using the average sector altitude, the average range for all areas covered by that sector, and the charge that has been designated as standard.

(3) *Phase III-refinement.* As time is available (unlikely if frequent moves are made), average site values are refined by computing two or three sites for each contour sector to evaluate those changes caused by significant differences in range. For example, site would be computed for the 300-330 contour sector at ranges 5000, 6000, 7000, etc.

*e. Multiple Missions.* The battery FDC must be able to process two or more missions at once. Although FADAC can process several missions independently, corrections for one mission cannot be applied while FADAC is computing data for another mission.

(1) When a battery receives two missions, the battery FDC processes both. The first mission is continued on FADAC. The second mission is processed on the chart (until FADAC becomes available after completion of its current mission). If the second mission is significantly more complex (such as a nuclear fire mission), it may be processed in FADAC. The first mission is transferred to the chart and manual backup techniques are used.

(2) A well-trained battery FDC might be able to compute data for three missions at once. However, if it cannot and if more than two missions are sent to the same battery, the battery FDC continues processing the first two unless the new mission is more urgent. Battalion FDC may process the new mission or allocate it to another battery that is not overloaded.

(a) If another battery is available and little time will be lost transferring the mission, battalion FDC should assign it the new mission. Two communications methods are possible.

1. Have the battery FDC assigned the mission switch its CF radio to the requesting observer's net (remain responsive to its own observers on its FD net with the other radio).

2. Have the battalion FDC relay the observer's call for fire and subsequent corrections to the battery assigned the mission using the battalion CF net.

(b) If another battery is not available or too much time will be lost transferring the mission, battalion FDC will compute firing data and send data to the FDC of the original battery. Sequence of firing of the missions will depend upon their relative urgency and how many guns are already involved in other missions. Several solutions are possible, including:

1. Suspend a lower priority mission until completion of the new mission.

2. Delay the latest mission until a higher priority mission is completed.

*Note.* Use one gun to adjust each mission, firing the entire battery in effect as each mission approaches completion.

## ★ 2-22. Sample Mission

The battery fire order and fire command elements in figure 2-7 are in effect for the following missions.

*a. FDC With FADAC.* The following mission is received in the battery FDC from the FIST:

T36 THIS IS T49. ADJUST FIRE.  
OVER.

(1) The RATELO announces

**FIRE MISSION**

to the FDC. The computer immediately announces

**FIRE MISSION**

to the guns.

(2) The RATELO continues to read back the FIST call for fire insuring that he has proper authentication.

GRID 359 286 OUT INFANTRY  
DIGGING IN. ICM IN EFFECT  
AUTHENTICATE LIMA ZULU  
OVER

| FIRE ORDER STANDARDS                                   |                        |
|--------------------------------------------------------|------------------------|
| ELEMENT                                                | CURRENT STANDARD       |
| UNIT TO FIRE                                           | <i>BTRY</i>            |
| ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT  | <i>#3 ①</i>            |
| BASIS FOR CORRECTIONS                                  | <i>FASTEST METHOD</i>  |
| DISTRIBUTION                                           | <i>PARALLEL SHEAF</i>  |
| PROJECTILE                                             | <i>HE</i>              |
| AMMUNITION LOT AND CHARGE                              | <i>XY/4</i>            |
| FUZE                                                   | <i>Q</i>               |
| NUMBER OF ROUNDS                                       | <i>①</i>               |
| RANGE SPREAD, LATERAL SPREAD, ZONE FIRE, OR SWEEP FIRE | <i>CTR RG &amp; DF</i> |
| TIME OF OPENING FIRE                                   | <i>WHEN READY</i>      |

| FIRE COMMAND STANDARDS                         |                  |
|------------------------------------------------|------------------|
| ELEMENT                                        | CURRENT STANDARD |
| WARNING ORDER                                  |                  |
| PIECES TO FOLLOW/PIECES TO FIRE/METHOD OF FIRE | <i>#3 ①</i>      |
| SPECIAL INSTRUCTIONS                           |                  |
| PROJECTILE                                     | <i>HE</i>        |
| AMMUNITION LOT                                 | <i>XY</i>        |
| CHARGE                                         |                  |
| FUZE/FUZE SETTING                              | <i>Q</i>         |
| DIRECTION                                      |                  |
| QUADRANT ELEVATION                             |                  |
| METHOD OF FFE                                  |                  |

★ Figure 2-7. Battery fire order/fire command standards.

(3) The other members of the FDC monitor the call for fire.

(a) The HCO inputs the grid in FADAC.

(b) The VCO plots the target on the firing chart and on the map. He determines and announces the altitude.

(c) The FDO inspects the target plot on the situation map and firing chart.

(d) The battalion FDO monitors the call for fire.

(4) The battery FDO decides on his plan of attack and announces his fire order.

**USE FADAC, 6 ROUNDS, VT IN EFFECT.**

(5) The fire order triggers several simultaneous actions:

(a) The HCO enters appropriate overrides and computes data with the FADAC.

(b) Using the fastest method, the computer determines and announces initial fire commands (up to fuze setting) to the guns.

(c) The RATELO determines and transmits the message to observer and receives OT direction from the observer.

(d) The battalion FDO, who has monitored the mission, will check the MTO. If he agrees, he will remain silent.

(6) When FADAC data is displayed, the computer reads it from the display panel and announces it to the cannon sections.

(7) The VCO determines site and announces it to the computer when required. He also determines angle T and announces it to the RATELO. The RATELO sends angle T to the observer if it is equal to or greater than 500 mils, and the computer records it on the record of fire.

(8) When the adjusting piece fires, **SHOT** is announced to the computer, who repeats **SHOT**. The RATELO then sends **SHOT, OVER** to the observer.

(9) The observer sends his subsequent corrections.

**DIRECTION 6100, LEFT 60, DROP 100, FIRE FOR EFFECT, OVER.**

(a) The HCO enters the observer's corrections in FADAC.

(b) The computer announces the change in method of fire to the guns.

(10) When FADAC data is displayed, it is sent to the guns. **SHOT** is sent to the observer when the guns fire.

(11) When each gun has fired six rounds, it announces **ROUNDS COMPLETE** to the computer. When all guns have reported, the computer announces **ROUNDS COMPLETE** to the RATELO who transmits **ROUNDS COMPLETE** to the observer.

(12) If the fire is sufficient, the observer sends refinement, end of mission, and surveillance to the RATELO.

(13) The FDO announces **END OF MISSION**. The HCO determines and announces refinement data and gives end of mission (EOM) to FADAC, the computer announces **END OF MISSION** to guns, the VCO pulls his pin from the firing chart.

*b. FDC Without FADAC.* If the FDC does not have a FADAC capability, the sequence of duties is altered.

(1) The HCO is the primary chart operator. As such, he plots the target and announces chart range and deflection for the initial grid and for subsequent corrections. He determines angle T.

(2) The VCO determines site, announcing it to the computer when requested, and follows the mission on his chart to provide a positive check on the HCO's data.

(3) Using his GFT, the computer converts the announced chart data into firing data and sends it to the guns.

*c. FDC Using Fastest Method.* Using the GFT fan is usually faster than using FADAC in determining initial data. When the FDC establishes FASTEST METHOD as his basis for corrections, FDC procedures to determine initial data outlined below should be used.



## FDC PROCEDURES

| STEP |                                                                                                                                                                                                                                                                                                                                                             | STEP |                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | RATELO—Receive warning order for an adjust fire mission.                                                                                                                                                                                                                                                                                                    | 10   | HCO—Enter overrides as appropriate.                                                                                                                                                                                                                                                                                                                                                                                 |
| 2    | FDO—Plot the target on the situation map and analyze the situation.                                                                                                                                                                                                                                                                                         | 11   | VCO—Mentally add the GFT deflection correction to the chart deflection. Add the drift correction from the ballistic scale to the sum and announce the result to the computer as <b>DEFLECTION (—)</b> . This is the deflection to fire (CHT DF + GFT DF CORR + DRIFT CORR). Ideally, it should be announced as soon as the computer states <b>CHARGE(—)</b> to the guns but not before, since the computer is busy. |
| 3    | Computer—Alert the guns by announcing <b>FIRE MISSION</b> . Then, if it is a grid mission, pick up the site map, plot the target, and announce the average altitude to the HCO. Record the average site. If it is a polar plot/shift mission, prepare to compute the vertical interval (VI) as soon as the VCO announces the observer/known point altitude. | 12   | RATELO—Send the MTO.                                                                                                                                                                                                                                                                                                                                                                                                |
| 4    | HCO—Enter data according to observer's method of target location.                                                                                                                                                                                                                                                                                           | 13   | Computer—Announce <b>DEFLECTION (—)</b> to the guns.                                                                                                                                                                                                                                                                                                                                                                |
| 5    | VCO—Plot the target on the chart. First, announce the observer/known point altitude to the computer if the mission is polar plot or shift.                                                                                                                                                                                                                  | 14   | VCO—Announce the elevation and chart range to the target to the computer as soon as he announces <b>DEFLECTION (—)</b> to the guns but not before, since he is busy.                                                                                                                                                                                                                                                |
| 6    | RATELO—Read back the mission and authenticate.                                                                                                                                                                                                                                                                                                              | 15   | Computer A—If average site can be used (i.e., if it is a grid mission), mentally add average site to the VCO's elevation and announce <b>QUADRANT (—)</b> to the guns.                                                                                                                                                                                                                                              |
| 7    | FDO—Issue the fire order.                                                                                                                                                                                                                                                                                                                                   | 16   | Computer B—If it is a polar plot/shift mission, use the chart range determined by the VCO in step 5 and the vertical interval determined as part of step 3 to compute site with the GST. Noting that the vertical interval could already be set off on the D-scale as part of step 3, this should enable the computer to rapidly determine site and, hence, quadrant elevation.                                     |
| 8    | FDO—Supervise.                                                                                                                                                                                                                                                                                                                                              |      |                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 9    | Computer—Announce fire commands to the guns up to and including charge.                                                                                                                                                                                                                                                                                     |      |                                                                                                                                                                                                                                                                                                                                                                                                                     |

*Note.* This procedure is written for an adjust fire mission when an average site map is available. If no average site map is available or if the mission is an FFE mission in which speed is desirable, the procedure still works except that the computer announces the actual target altitude (also as part of step 3) to determine and set off the VI he needs. If accuracy is more important than speed, the FDO might want to specify **USE FADAC** or **USE GFT** in his fire orders. Normal manual procedures would then apply.

## Section VI. BATTALION MISSION PROCESSING

### ★ 2-23. Battalion Responsibilities

a. The battalion FDO must monitor all calls for fire on all nets. Battalion FDC will become involved in a mission in one of two ways:

(1) *Missions submitted directly to battalion FDC.* These may come from higher headquarters, fire support officers, or FISTs.

(2) *Missions submitted to battery FDCs.* The battalion FDO may decide to step in and mass the battalion on a target sent directly to the battery that is monitored by the battalion

computer on that battery's fire direction net or the battery FDO may request additional fires.

b. Subsequent corrections will be sent to any battery not able to monitor the conduct of the mission.

### ★ 2-24. Sample Missions

a. The battalion standard fire order elements in figure 2-8 are in effect for the following mission.

b. A fire for effect mission (TOT designated from division artillery direct to battalion FDC):

| FIRE ORDER STANDARDS                                         |                  |
|--------------------------------------------------------------|------------------|
| ELEMENT                                                      | CURRENT STANDARD |
| UNIT TO FIRE                                                 | BTRY             |
| ADJUSTING ELEMENT/<br>METHOD OF FIRE OF<br>ADJUSTING ELEMENT | BP ①             |
| BASIS FOR CORRECTION                                         | FASTEST METHOD   |
| DISTRIBUTION                                                 | PARALLEL SHEAF   |
| PROJECTILE                                                   | HE               |
| AMMUNITION LOT AND CHARGE                                    | A:WT/4; B&C WT/5 |
| FUZE                                                         | Q                |
| NUMBER OF ROUNDS                                             | ①                |
| RANGE SPREAD, LATERAL<br>SPREAD, ZONE FIRE,<br>OR SWEEP FIRE | CENTER RG & DF   |
| TIME OF OPENING FIRE                                         | WHEN READY       |

★ Figure 2-8. Battalion standard fire order elements.

## Bn FDC

## Btry FDCs

(1) Battalion FDC receives mission from division artillery on radioteletypewriter (RATT):

THIS IS DIV FIRE FOR EFFECT  
BATTALION GRID 61723618  
ALTITUDE 380. BATTALION  
ASSEMBLY AREA. FOUR ROUNDS  
ICM. TIME ON TARGET 0915.

(2) FDO issues fire order:

FIRE FOR EFFECT, BATTALION,  
GRID 61723618, ALTITUDE 380,  
SHELL ICM, LOT ZULU TANGO,  
FUZE TIME, FOUR ROUNDS, TIME  
ON TARGET 0915.

(3) A, B, C, computers to batteries (wire lines):

FIRE FOR EFFECT, BATTALION,  
GRID 61723618, ALTITUDE 380,  
SHELL ICM, LOT ZULU TANGO,  
FUZE TIME, FOUR ROUNDS, TIME  
ON TARGET 0915.

(1) All batteries read back:

FIRE FOR EFFECT, BATTALION,  
GRID 61723618, ALTITUDE 380,  
SHELL ICM, LOT ZULU TANGO,  
FUZE TIME, FOUR ROUNDS, TIME  
ON TARGET 0915.

(2) Batteries compute data and send to guns.

(4) Battalion FDO on battalion CF net.

AT MY MARK THE TIME WILL BE  
0915. MARK OVER.

*Note.* This time check could have been sent individually to each battery using the fire nets or wire lines.

(3) Battery A:

ROGER, OUT.

Battery B:

ROGER, OUT.

Battery C:

ROGER, OUT.

## REMARKS:

The batteries would now control their own firing, reporting **SHOT** and **ROUNDS COMPLETE** to battalion FDC. Battalion FDC would report firing to div arty.

# CHAPTER 3

## CHART DATA

### Section I. FIRING CHARTS

#### 3-1. Definition

The firing chart is normally a grid sheet that is used to graphically show the location of batteries, targets, and other details needed to determine chart data.

#### 3-2. Purpose, Types, and Use of Firing Charts

a. The purpose of a firing chart is to determine the range and direction from the guns to the target. Effective artillery fires require an accurate and complete firing chart.

★ b. There are three types of firing charts used in the FDC—the surveyed firing chart, the observed firing chart, and the emergency firing chart. This chapter will deal with surveyed firing charts.

(1) The surveyed firing chart (fig 3-1) is a chart on which the locations of all critical points (e.g., battery positions, registration points, observation posts (OP)) are plotted. These locations can be based on survey or map inspection. All plotted points are in correct relation to one another and reflect actual map coordinates. When actual map coordinates are unknown, assumed coordinates may be used initially to tie together the points plotted.

(2) Details of construction and use of the observed firing chart are in chapter 15.

(3) Details of construction and use of the emergency firing chart are in chapter 14.

c. The firing chart used in an FDC is normally a grid sheet on which all essential points are plotted. Essential locations include:

- (1) Firing batteries.
- (2) Observation posts.

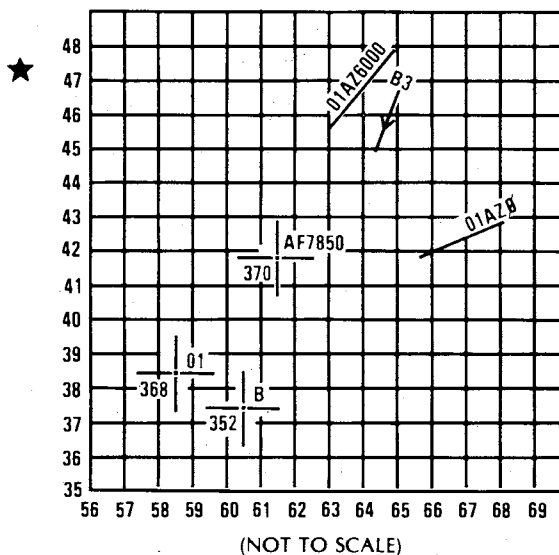


Figure 3-1. A surveyed firing chart.

- (3) Registration points.
  - (4) Field artillery radars.
  - (5) Final protective fires.
  - (6) Targets as requested by the observer or directed by the FDO.
  - (7) Other points related to the tactical situation as desired by the commander.
- d. In the FADAC integrated FDC (FADAC and manual backup), the firing chart is

maintained by the VCO and supplemented by a 1:50,000 map used to determine altitude. A situation overlay will be maintained with this map. Based on the tactical situation and the desires of the commander, additional overlays (e.g., fire capabilities, dead space overlays) may be maintained. In a manual FDC, two firing charts are maintained. The VCO will maintain his chart and the 1:50,000 supplementary map with the overlay(s), and the HCO will maintain the other firing chart.

## Section II. PLOTTING EQUIPMENT AND PREPARATION OF FIRING CHARTS

### 3-3. Plotting Rules

Fire direction personnel must insure the accuracy of the data shown on the firing chart. All firing charts in the battalion should be identical so fires may be massed accurately. To insure accuracy, plotting should be done from a standing position directly above the chart. Plotting pins must be kept perpendicular to the firing chart.

### 3-4. Equipment

Special equipment is used to construct and use a firing chart. This equipment must be maintained and used properly to insure maximum accuracy.

a. *6H Pencil.* The 6H (hard lead) pencil, sharpened to a wedge point (fig 3-2), is used to draw all lines from which measurements will be made.

b. *4H Pencil.* The 4H pencil, sharpened to a conical point (fig 3-2), is used to letter and to accentuate tickmarks.

c. *Plotting Pins.* Plotting pins are used to mark positions and to plot points on the firing chart.

d. *Aluminum Plotting Scale.* The aluminum plotting scale (fig 3-3①) is a

square-shaped scale used to plot or determine grid coordinates of targets and critical points. The scale is graduated in meters and yards at scales of 1:25,000 and 1:50,000. Locations may be plotted to an accuracy of 1 meter with the aluminum plotting scale.

e. *Plotting Scale.* The plotting scale (fig 3-3②) can be used to measure distances and to plot or determine grid coordinates of critical points when the aluminum plotting scale is not available. The scale is graduated in meters, yards, and inches. The meter and yard graduations are at scales of 1:25,000, 1:50,000, and 1:62,500. The scale should never be used as a straightedge to draw lines.

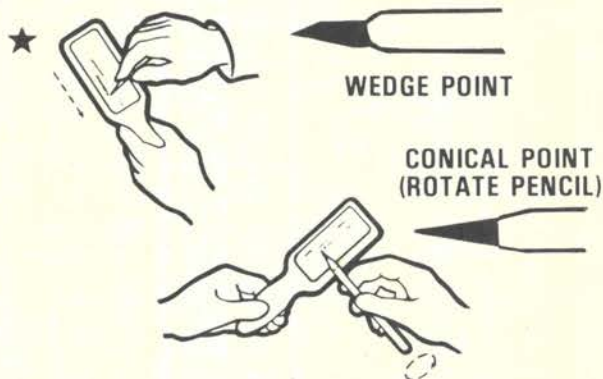
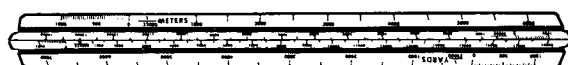


Figure 3-2. 6H and 4H pencil points.



② PLOTTING SCALE

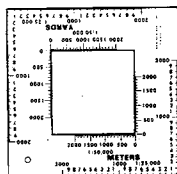
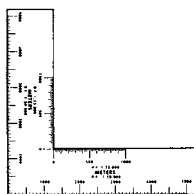
① PLOTTING SCALE  
(ALUMINUM)③ PLOTTING SCALE  
(PLASTIC)

Figure 3-3. Scales used in fire direction.

Locations may be plotted to an accuracy of 1 meter with the plotting scale.

- ★ *f. Plastic Plotting Scale.* The plastic plotting scale (fig 3-3 ③) may be used to plot or determine coordinates of targets other than registration points and locations determined by survey when an aluminum plotting scale is not available. The scale is graduated in meters and yards at scales of 1:25,000 and 1:50,000. Locations may be plotted to an accuracy of 10 meters with the plastic plotting scale.

*g. Range-Deflection Protractor.* The range-deflection protractor (RDP) (fig 3-4) is used to measure angles and distances. It is used to measure range and deflection from a battery to a target and to measure direction and distance from an observer to a target. The left edge of the arm is graduated in 50-meter increments at a 1:25,000 scale. It is read to a visually interpolated accuracy of 10 meters. The 1000-mil arc of the RDP is graduated in 5-mil increments. The 50-mil increments are indicated by a long line. The arc is read to a visually interpolated accuracy of 1 mil.

### 3-5. Numbering

The firing chart is numbered to correspond to the mapped area of the zone of action. The lower left-hand corner of the grid sheet is assigned easting and northing coordinates

that will insure covering the area of operations. If applicable, the direction of the long axis (east-west or north-south) will be designated. There must be enough space to plot all necessary points on the chart. The firing chart is numbered with a 4H pencil. The rightmost and topmost grid lines are not labeled.

### 3-6. Plotting

a. For critical points and points located by survey, proceed as follows:

(1) *Grid lines 1000 meters apart (fig 3-5).*

- ★ (a) Locate and place a plotting pin in the grid square in which the point is to be plotted (fig 3-5).

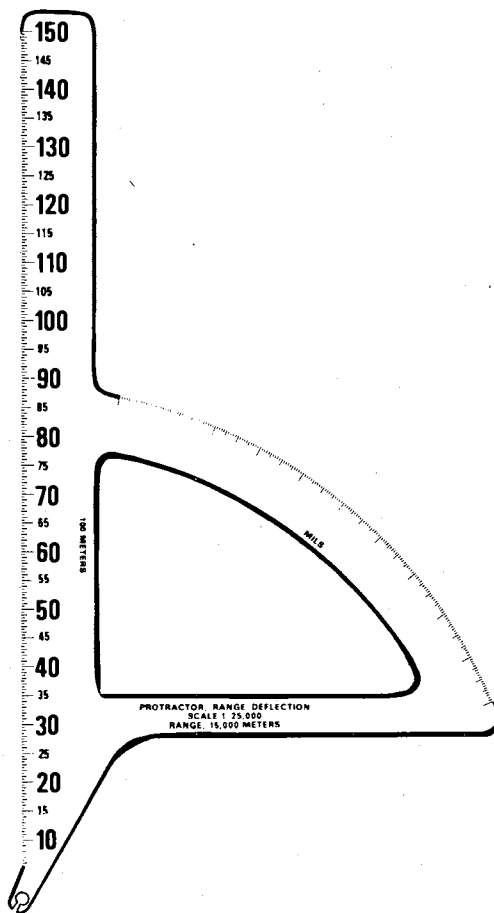


Figure 3-4. Range-deflection protractor.

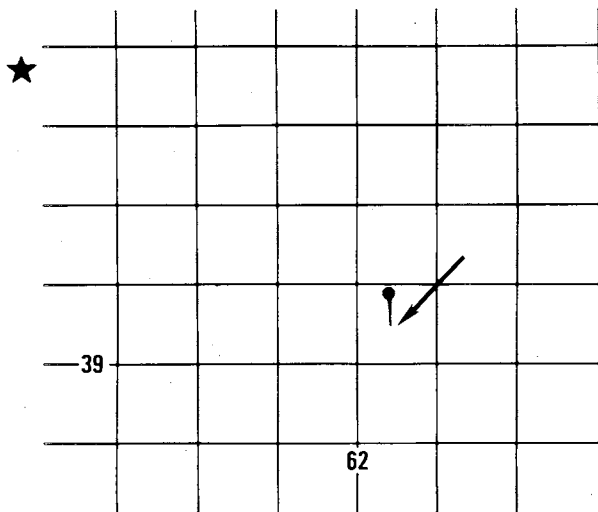


Figure 3-5. Square in which point is to be plotted.

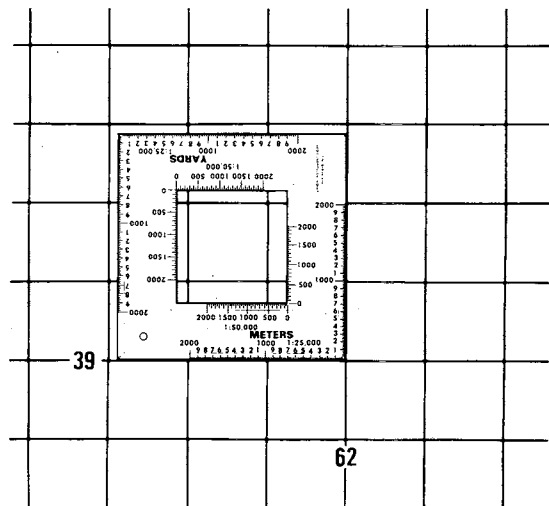


Figure 3-6. Use of the plotting scale.

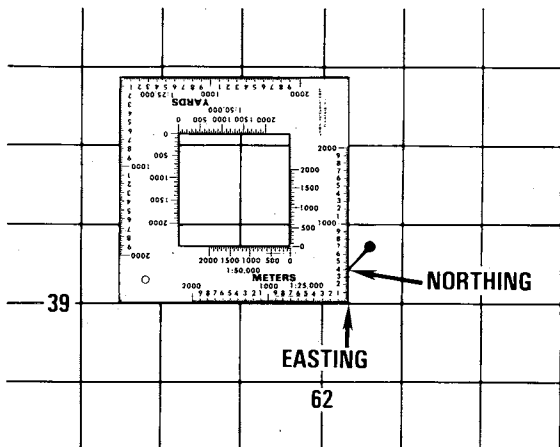


Figure 3-7. Plotting the point using the plotting scale.

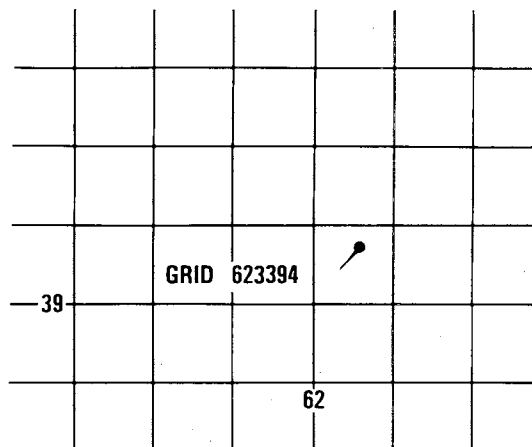


Figure 3-8. The plotted location.

(b) Place the aluminum plotting scale along the left edge of the grid square with the zero of the scale at the lower left corner of the grid square (fig 3-6).

(c) Slide the scale to the right; read the easting on the scale using the N-S grid line as an index (fig 3-7).

(d) Plot the northing on the vertical scale using a plotting pin. This is the plotted location (fig 3-8).

(2) *Grid lines not 1000 meters apart.*

(a) When grid lines are closer than normal, plot the point by inclining the

aluminum plotting scale so that the zero of the scale is on one grid line and the 1000 is on the other (fig 3-9).

(b) If the grid lines are farther apart than normal, incline the aluminum plotting scale so that the zero of the scale is on one grid line and 2000 is on the other (fig 3-10). Multiply the distance to be plotted by 2 and plot the point. For example, for an easting of 62681, place the pin at 1362 on the scale.

(c) In both cases, only easting or northing can be plotted at one time. Therefore, the following four-point plotting



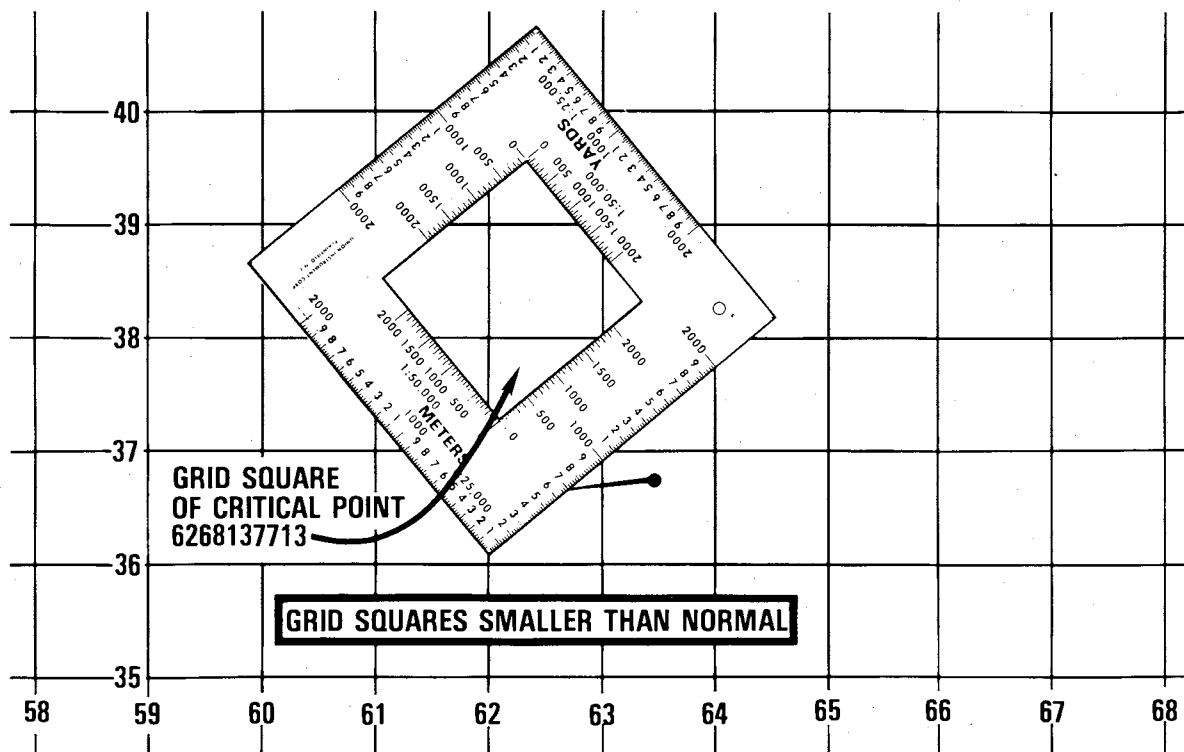


Figure 3-9. Grid squares smaller than normal.

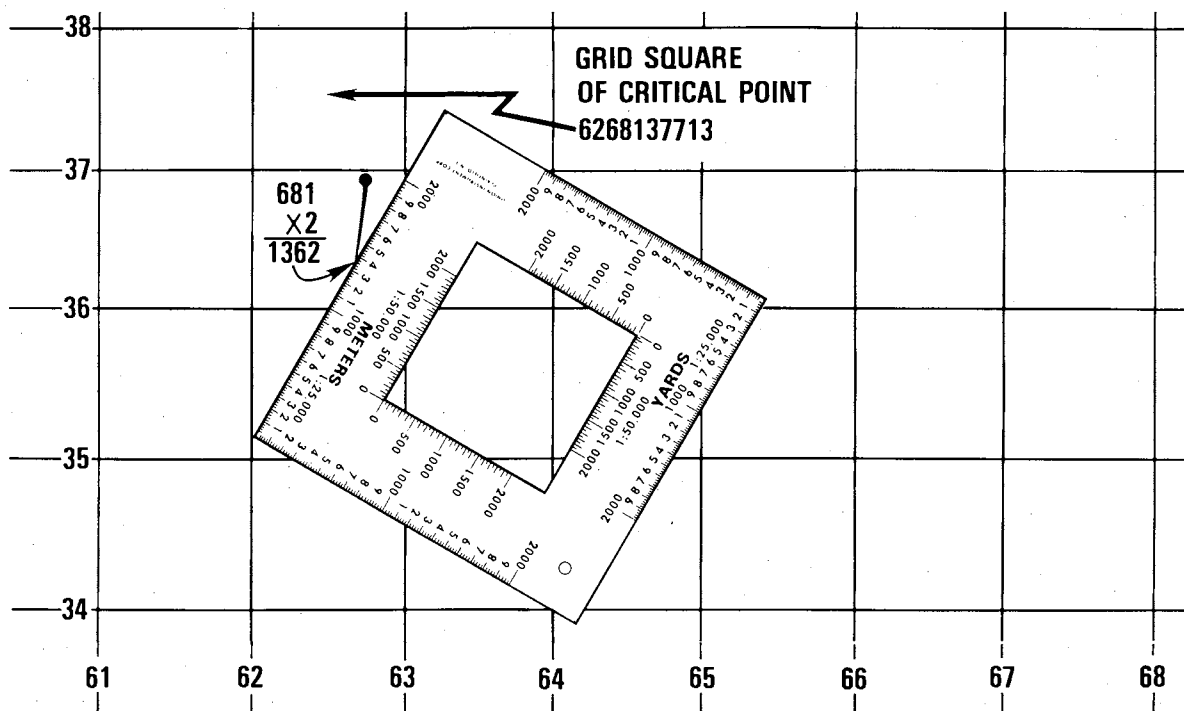


Figure 3-10. Grid squares larger than normal.

technique must be used to plot a point located by survey when grid lines are not 1000 meters apart.

1. Locate the grid square in which the point is to be plotted.

2. Using plotting pins and the aluminum plotting scale, plot the easting grid in the grid squares above and below the grid square in which the point is to be located. Remove the pins and connect the points with a fine line drawn with a 6H pencil through the center of the pinholes (fig 3-11).

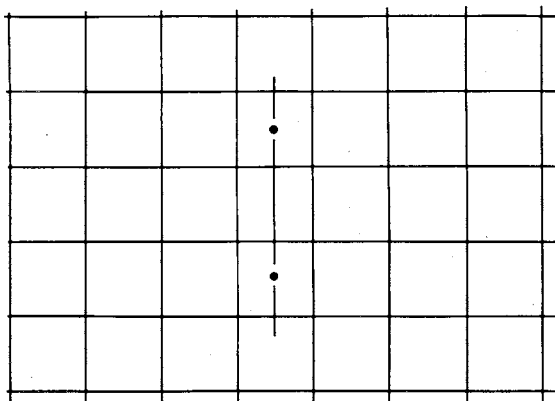


Figure 3-11. Plot the easting grid.

3. Plot the northing grid in the grid squares to the left and right as in step 2 (fig 3-12). Connect the pinholes with a line drawn with a 6H pencil.

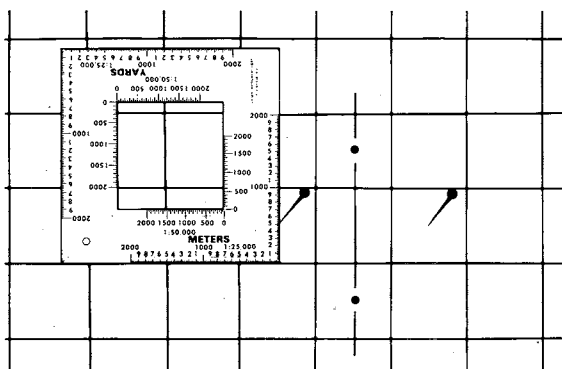


Figure 3-12. Plot the northing grid.

4. Mark the point where the two lines meet with a plotting pin (fig 3-13). Erase the fine lines and identify the location with a tickmark (fig 3-14).

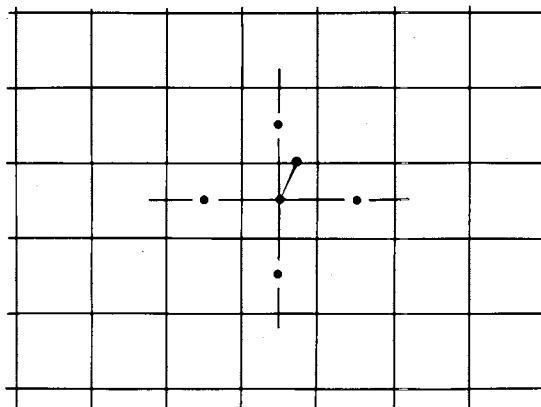


Figure 3-13. Mark the point where the two lines meet.

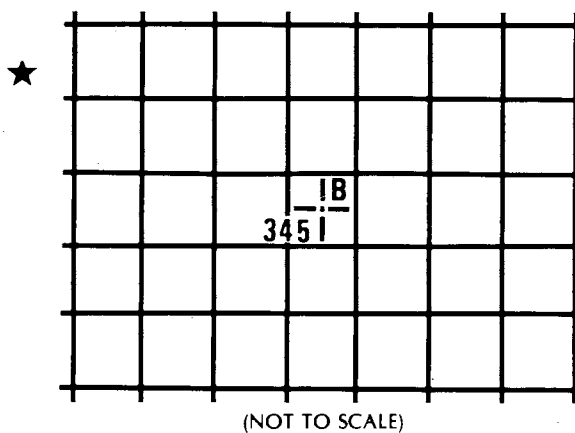


Figure 3-14. Identify the location with a tickmark.

b. Noncritical points are plotted in the same manner as points located by survey when grid lines are 1000 meters apart (para a(1) above).

★ c. The plastic plotting scale may be used in place of the aluminum plotting scale. When it is used, the four-point plotting technique as described in paragraph a(2)(c) above must be used.

### 3-7. Tickmarks

The tickmark is the symbol used to mark and identify the location of installations and targets plotted on a firing chart.

a. The tickmark is constructed in the form of a cross starting 40 meters from the pinhole on the chart and extending 150 meters in length (1:25,000 scale) (fig 3-15 ①). The

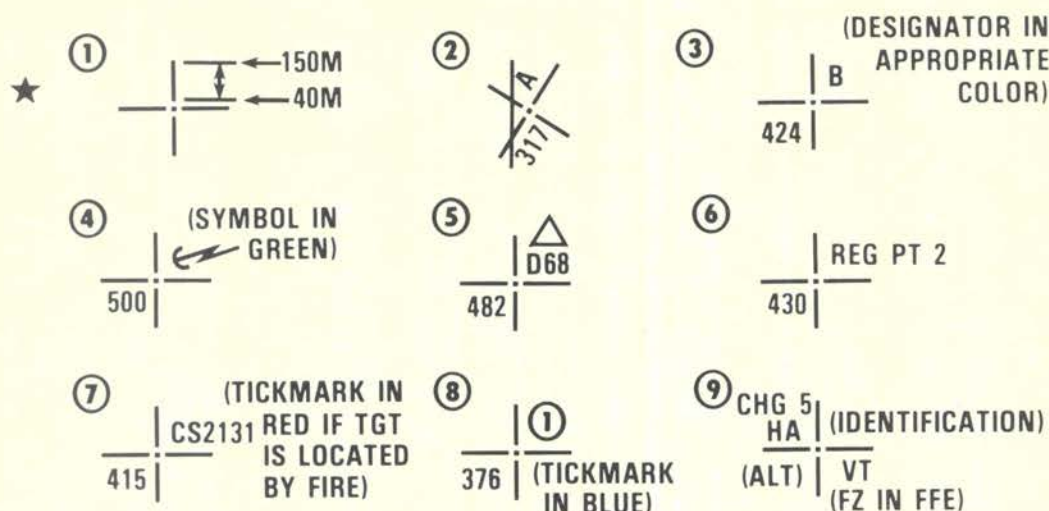


Figure 3-15. Tickmarks.

lines of the tickmark are drawn parallel to the grid lines unless the point falls on or close to a grid line, in which case it is plotted at a 45-degree angle to the grid line (fig 3-15 ②). All tickmarks are drawn with a 4H pencil except targets located by firing, which are drawn in red, and maneuver checkpoints, which are drawn in blue.

b. The identification of the point is placed in the upper right quadrant. The installation or activity is designated in the following manner.

(1) *Battery*. The letter designation is shown in the appropriate color (fig 3-15 ③); i.e., A-red, B-black, C-blue, D-orange. If more than four batteries are shown, the color coding starts over again with red. If the pieces of the battery are widely dispersed, it may be necessary to plot piece or platoon locations.

(2) *Radar*. The military symbol is shown in green (fig 3-15 ④).

(3) *Observation post*. The military symbol and call number of the observer are shown in black (fig 3-15 ⑤). If the observation post is assigned a number, that number is shown in black in place of the symbol and call number (e.g., O2).

(4) *Registration points*. The number assigned to the point is shown in black; e.g., REG PT 2 (fig 3-15 ⑥).

★ (5) *Targets*. The assigned target number is shown in black; e.g., CS2131 (fig 3-15 ⑦).

(6) *Checkpoints*. The checkpoint number is shown in black and circled; e.g., ① (fig 3-15 ⑧).

c. The altitude, in meters, of the plotted point is placed in the lower left quadrant in black (fig 3-15 ③—⑦).

### IDENTIFICATION AND ALTITUDE MUST ALWAYS BE GIVEN.

d. If the plotted point has been fired upon, the fuze used in fire for effect may be placed in the lower right quadrant (fig 3-15 ⑨).

e. If the plotted point has been fired upon with high angle fire, the letters HA may be placed in the upper left quadrant (fig 3-15 ⑨).

f. The charge fired may be placed in the upper left quadrant (fig 3-15 ⑨).

### 3-8. Establishing Azimuth Indexes

a. Azimuth indexes are established for points located on the firing chart from which the polar plot method (see para 3-14b) of target location may be expected; e.g., observation posts and radar sites. The RDP must be prepared by numbering the 100-mil graduations in black as shown in figure 3-16.

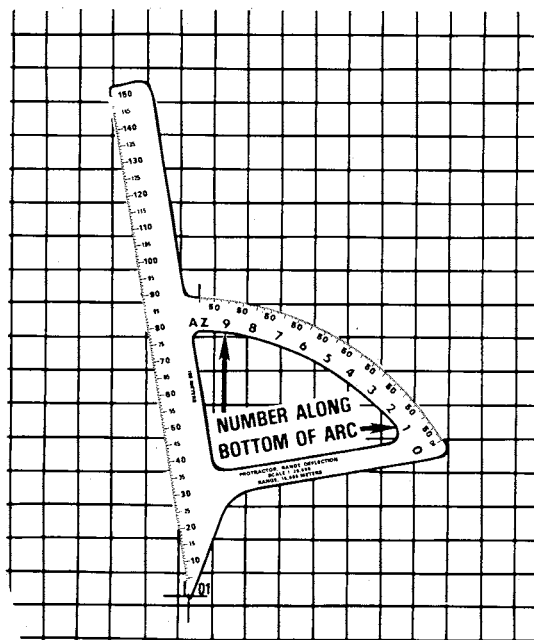


Figure 3-16. Prepared RDP.

b. Azimuth indexes are constructed on the firing chart at 1000-mil intervals throughout the target area. To construct the azimuth indexes:

(1) Place the vertex of the RDP against a pin in the OP or radar location and align the arm parallel to a convenient grid line. To align the arm parallel to a grid line, plot the easting of the observer if using a north-south grid line. If using an east-west grid line, plot the northing of the observer in a similar manner. When aligned, the arm establishes a reference line (not drawn) at an azimuth of 0

(north), 1600 (east), 3200 (south), or 4800 (west).

(2) Azimuth is always read as four digits. The first digit of the azimuth is read from the azimuth index on the chart. The last three digits are read on the arc of the RDP. In (1) above, the RDP was oriented in a cardinal direction. To establish the azimuth index, place a pin opposite the number on the arc corresponding to the last three digits of the azimuth in which the arm of the RDP is oriented. The location of the pin represents an azimuth with the value of the first digit of the

Table 3-1. Indexing Procedures

**If RDP is oriented NORTH = 6400 mils = 0 mils,**

1 Place pin opposite 400 on ARC, INDEX is 6000.

2 Place pin opposite 0 on ARC, INDEX is 0.

**If RDP is oriented EAST = 1600 mils,**

Place pin opposite 600 on ARC, INDEX is 1000.

**If RDP is oriented SOUTH = 3200 mils,**

Place pin opposite 200 on ARC, INDEX is 3000.

**If RDP is oriented WEST = 4800 mils,**

Place pin opposite 800 on ARC, INDEX is 4000.

azimuth in which the arm of the RDP is oriented. If the arm is oriented toward north, two azimuth indexes will be constructed, since north corresponds to 6400 or 0 mils (fig 3-17); e.g., 6000 and 0 AZ indexes. Table 3-1 summarizes indexing procedures for all orientations of the RDP.

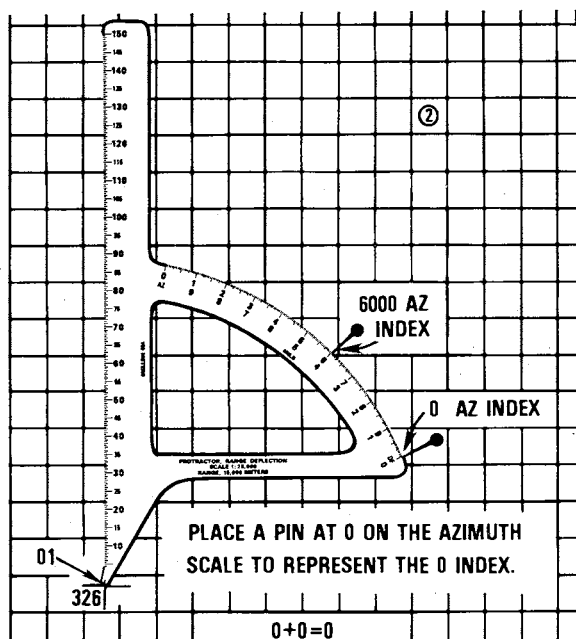


Figure 3-17. Construction of 6400-mil and 0-mil azimuth indexes.

(3) Move the RDP so the left edge of the arm is against the pin, remove the pin, and draw the azimuth index with a 6H pencil. The index is a fine line extending 1 inch above and 1 inch below the pinhole. This line can be measured by drawing a line from range 8250 to range 9520 along the left edge of the arm of the RDP. Beginning one-eighth inch beyond the pinhole, label the index with its identification (O1, 24, radar symbol) and azimuth value along the left side of the line.

★ Lettering is green for the radar symbol and its azimuth labels and black for OPs and their azimuth labels (fig 3-18).

(4) Other azimuth indexes can be constructed by measuring successive 1000-mil increments to the left and right of the first. To locate an index for 2000 mils, place a pin 1000 mils right of the index for azimuth 1000. The arc of the RDP is exactly 1000 mils.

To locate an azimuth index for 5000 mils, place a pin 1000 mils left of the index for 6000 mils.

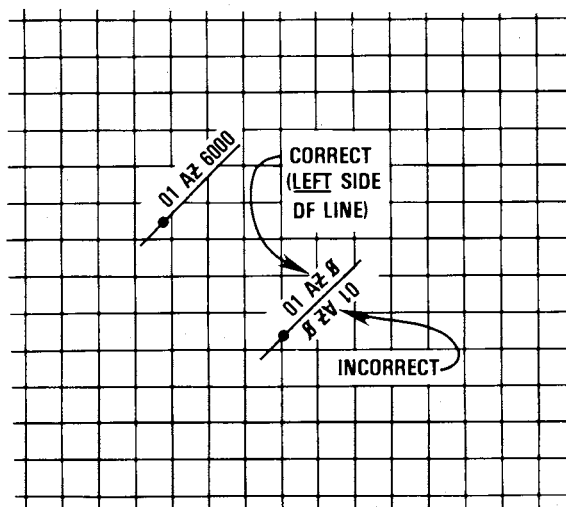


Figure 3-18. Labeling the azimuth indexes.

c. The value of the azimuth measured or plotted is the sum of the azimuth marked on the azimuth index plus the value read on the arc opposite the index (fig 3-19). In this example, the azimuth is 0750.

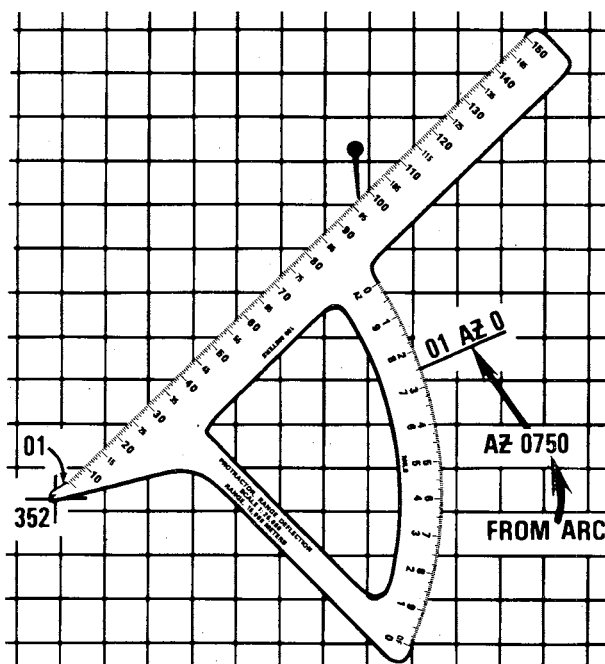


Figure 3-19. Measuring the value of the azimuth.

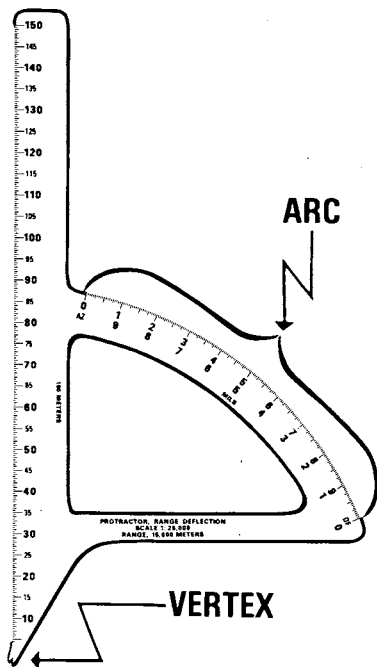


Figure 3-20. Parts of the range-deflection protractor prepared for measurement of deflection.

### 3-9. Establishing Deflection Indexes

Direction from a battery to a target normally is measured and announced in terms of deflection. The RDP must be prepared to measure deflection by numbering the graduations of the arc in red as shown in figure 3-20.

a. The deflection index is used with the RDP to determine chart deflection. The index is constructed as follows:

(1) With the vertex of the RDP against the pin in the battery position, orient the left edge of the arm in the direction of the battery's azimuth of lay. Using the procedure outlined in paragraphs 3-8b(1) and (2), place a pin in the chart where the azimuth index would be constructed (do not draw the index). In figure 3-21, the RDP is oriented to the east (1600 mils), and a pin is placed opposite 600 on the azimuth scale. Now move the RDP until the last three digits of the azimuth of fire (read on the azimuth scale of the RDP) are opposite the pin. The left edge of the RDP is now oriented in the direction of the battery azimuth of lay. Figure 3-22 depicts the RDP

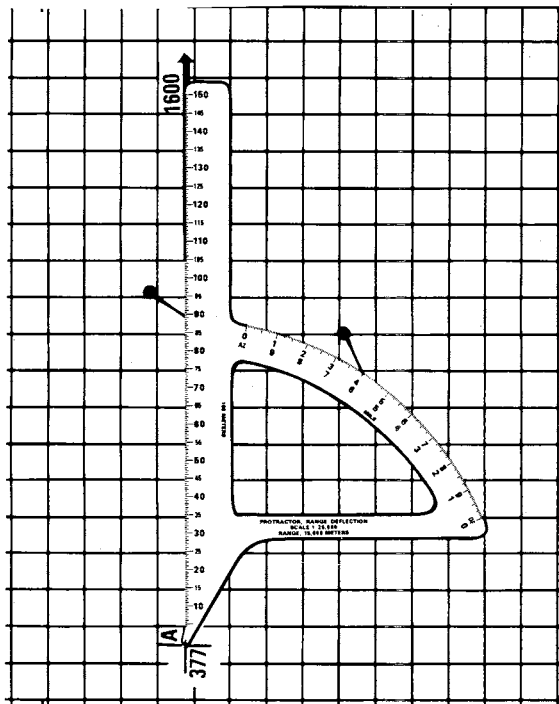


Figure 3-21. RDP oriented to the east.

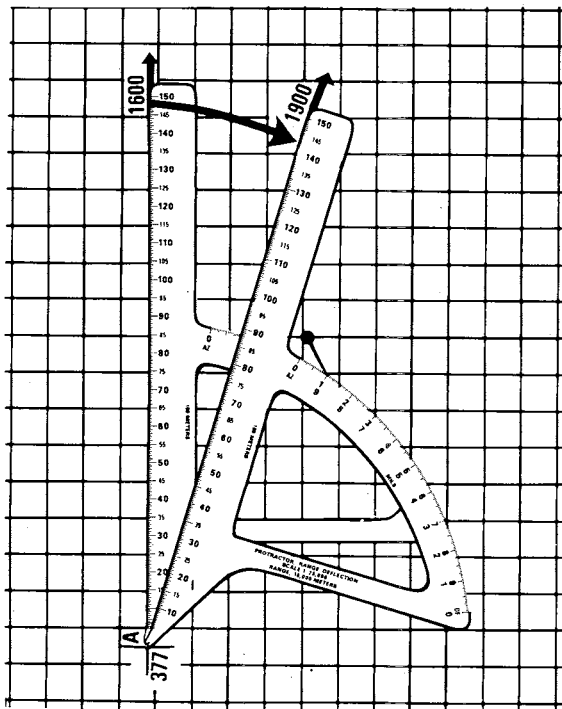


Figure 3-22. RDP oriented on azimuth of lay.

oriented on an azimuth of lay of 1900 mils. If the battery is laid on the direction to a registration point, place the left edge of the RDP against a pin in the registration point to orient the RDP.

(2) For the M100 series sight, the common deflection is 3200 mils. The firing chart must be constructed so that the azimuth of lay corresponds to the common deflection. To do this, orient the RDP on the azimuth of lay (as above) and place a pin opposite the 200-mil graduation on the deflection scale (fig 3-23). Move the RDP so the left edge of the arm is against the pin. Remove the pin and draw a fine line (with a 6H pencil) along the range scale, 1 inch above and 1 inch below the pinhole. Label this index with the appropriate battery designator and the number 3 in the appropriate color. Draw the arrowhead as shown in figure 3-24 in the appropriate color and one-eighth inch above the pinhole. (For the M12 series sight, with the common deflections of 2400 or 2800, the pin would be placed at 4 or 8, respectively, and the index would be labeled 2.)

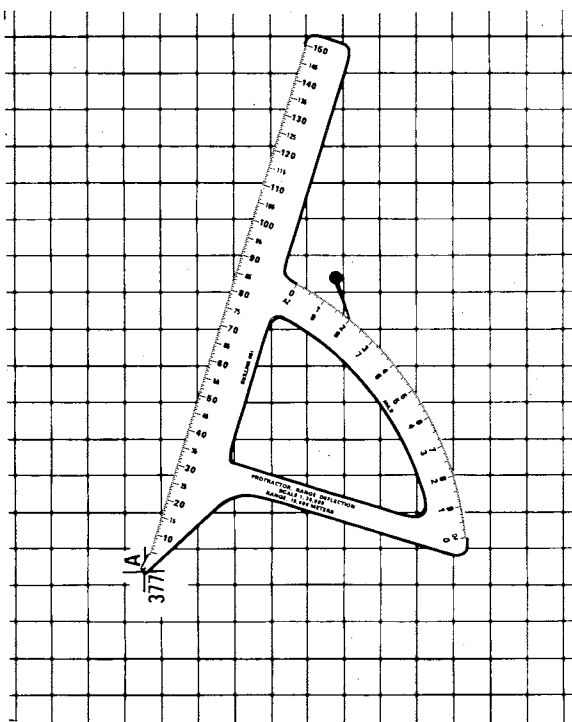


Figure 3-23. Construction of a common deflection index.

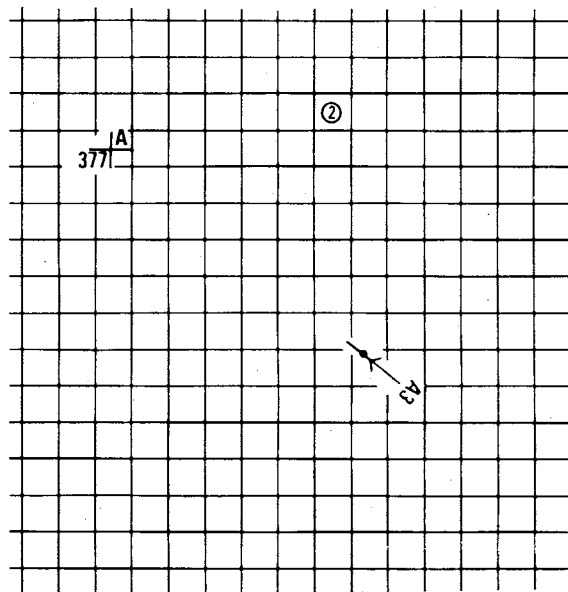


Figure 3-24. Construction of the deflection index.

★ b. Locate supplementary deflection indexes by constructing indexes 1000 mils left or right of the primary index. Since deflection increases to the left (LARS) and azimuth decreases, label the left index one number higher than the primary index. Conversely, as azimuth increases, deflection decreases to the right; therefore, label the right index one number lower than the primary index (fig 3-25).

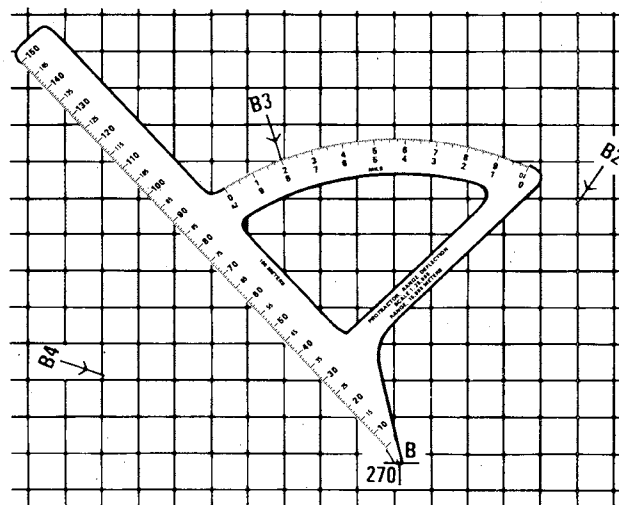


Figure 3-25. Supplementary deflection indexes.



## 3-10. 6400-Mil Charts

a. When firing in a 6400-mil sector is required, the batteries are plotted in the center of the firing chart. The indexes are constructed and numbered as shown in figure 3-26. Fabricated, larger charts may be necessary to achieve the maximum range throughout the 6400 mils.

b. When indexing the firing chart for 6400-mil capability, the chart operator may find that the RDP will measure a few mils more or less than 6400 mils. To insure that any errors are distributed evenly, construct the 4000-, 5000-, and 6000-mil indexes to the left of the 3000-mil index; then construct the 2000-, 1000-, and 0-mil indexes to the right of the 3000-mil index.

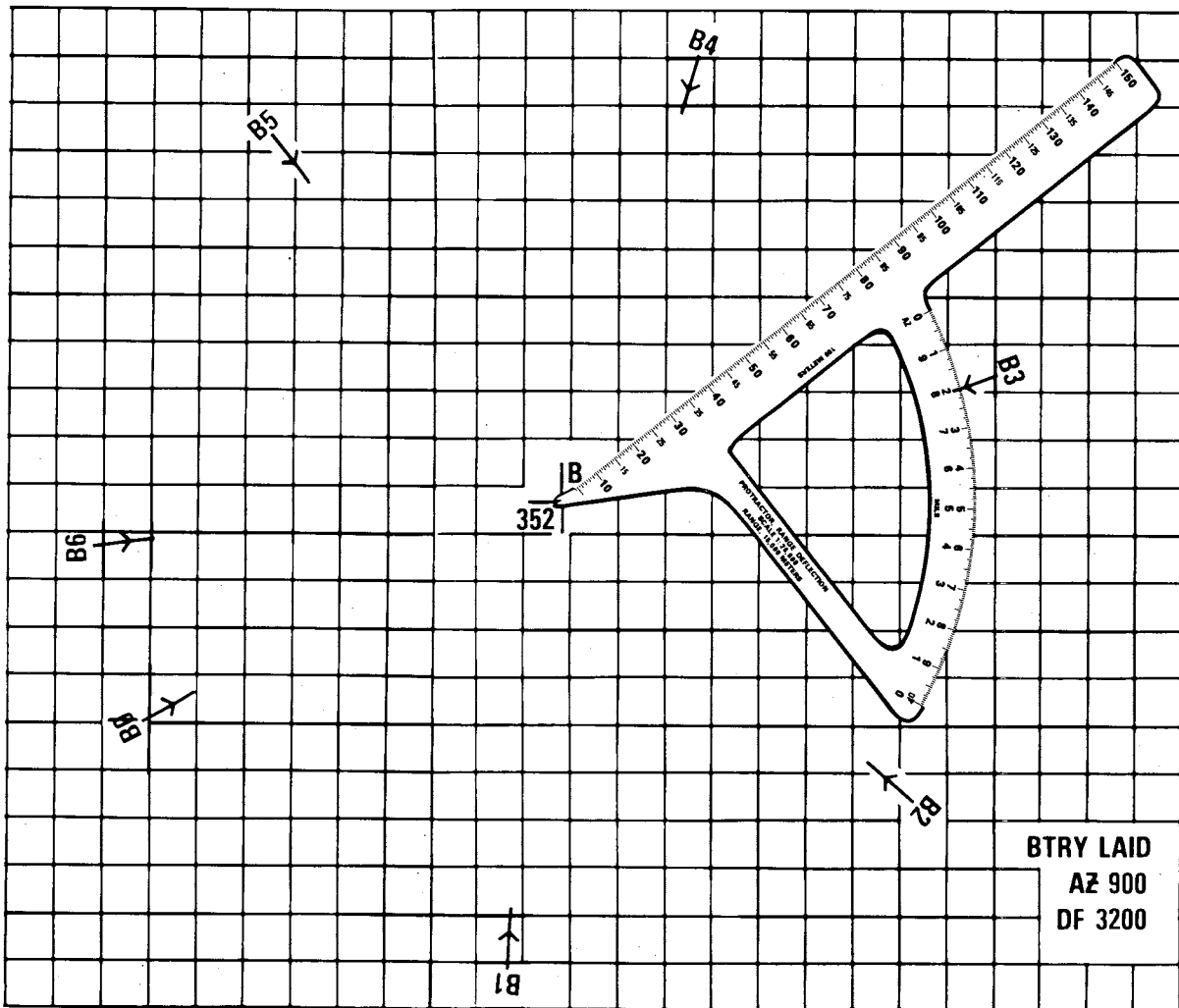


Figure 3-26. 6400-mil firing chart.

## Section III. DETERMINATION OF CHART DATA

### 3-11. Elements of Chart Data

There are three elements of chart data: chart range, chart deflection, and angle T. They are measured as follows:

a. Place the vertex of the RDP against the pin in the battery position and the left edge of the arm against the pin in the target location.

b. Read the range in meters opposite the pin in the target location. Measure and announce the range to the nearest 10 meters.

c. Read the chart deflection on the arc opposite the appropriate deflection index. Combine the 1000-mil designation of the index with the reading on the arc to obtain the deflection.

d. Angle T will be discussed in paragraph 3-13.

e. The format used by the HCO or VCO when announcing chart data to the computer is:

BRAVO RANGE \_\_\_\_\_  
DEFLECTION \_\_\_\_\_  
ANGLE T \_\_\_\_\_

### 3-12. Target Grid

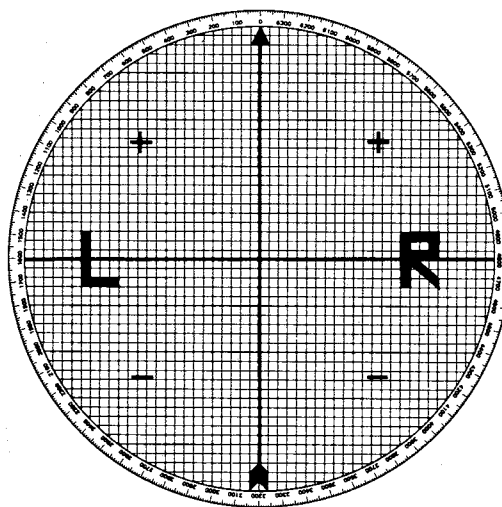
#### a. Description.

(1) A target grid is needed to determine chart data for shift missions, to measure angle T, and to plot subsequent corrections.

(2) The target grid is a device used to convert, by plotting, the observer's target locations and corrections with respect to the observer-target (OT) line (or other line of known direction) to target locations and corrections with respect to the gun-target (GT) line. The arrow extending across the target grid indicates the direction of the OT line. The azimuth scale is graduated in 10-mil increments and is numbered every 100 mils. The scale of the target grid must be made

equal to the firing chart. When a 1:25,000 firing chart is used, each square on the target grid is 100 meters on a side. The target grid should be labeled as shown in figure 3-27. Masking tape should be placed on the reverse side of the target grid at the center to prevent tears.

Lines connecting 0-3200 and 1600-4800  
should be drawn in blue



L, (—) DRAWN IN BLUE R, (+) DRAWN IN RED

Figure 3-27. Labeled target grid.

b. Positioning and Orienting the Target Grid. The center of the target grid is placed over the location of interest on the firing chart and fixed in position with a pin. To orient the target grid, align the arrow parallel to a north-south grid line, with the arrow pointing north. Place a pin opposite zero on the scale; then rotate the target grid until the OT direction is opposite the pin. The target grid is now oriented. In figure 3-28, the target grid is oriented in the direction reported by the observer, 1100 mils. For locations from which an observer may locate targets by shifting from a known point (para 3-14c), such as registration points or points recorded

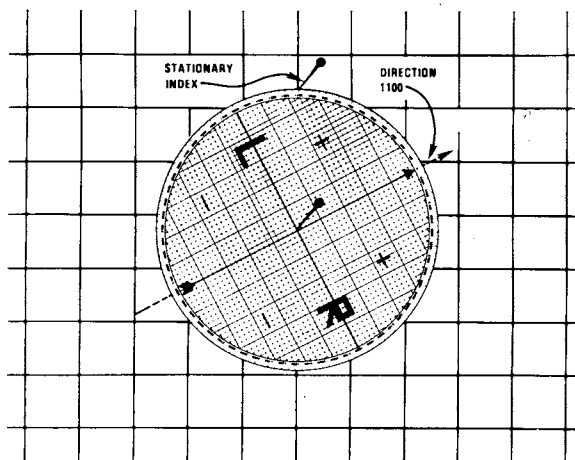


Figure 3-28. Target grid oriented in observer direction.

as targets, a north azimuth index should be constructed. Position and orient the target grid toward north as before. Instead of placing a pin opposite the zero, construct an index opposite zero (see fig 3-29). The index extends 1 inch above and 1 inch below the edge of the target grid. Mark the index "N" as shown in figure 3-29.

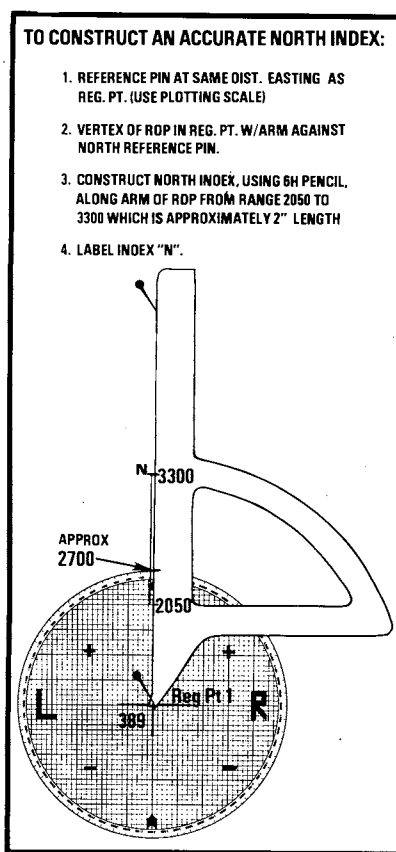


Figure 3-29. Construction of accurate North index.

### ★ 3-13. Angle T

Angle T (fig 3-30) is the horizontal interior angle formed at the target by the intersection of the gun-target line and the observer-target line. It may never be larger than 3200 mils. It is determined after the target grid is oriented over the initial target location along the observer's direction and the initial chart range and chart deflection are announced. Accuracy of angle T is 10 mils, determined and announced by the chart operator. It is measured in the following manner.

a. When the target grid is centered on the target, oriented along the observer direction, count the number of mils by increments between the point where the arm of the RDP intersects the azimuth scale of the target grid and 0 or 3200, whichever is visible to the left of the arm of the RDP.

b. When the pin is not centered on the target grid, measure angle T by reorienting the target grid over the plotted target so that

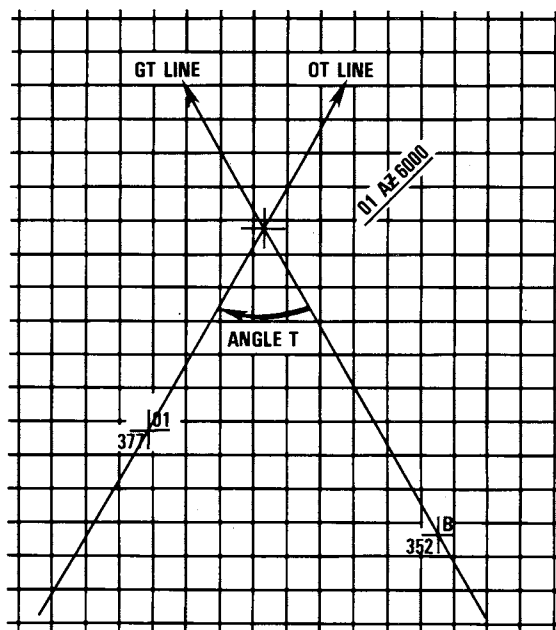


Figure 3-30. Angle T.

the pin is centered (preferred method) or place the RDP against the pin and record the number of mils at the top and bottom of the target grid between the point where the arms of the RDP intersect the azimuth scale (fig 3-31). If the RDP crosses the centerline (as in fig 3-31), add the two angles and divide by 2 to determine angle T. If the RDP does not cross the centerline, subtract the smaller angle from the larger angle and divide by 2 to determine angle T (fig 3-32).

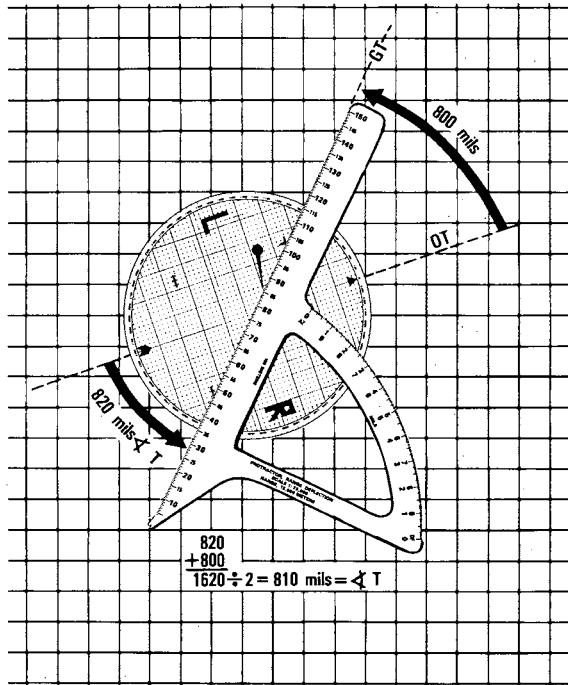


Figure 3-31. Determination of angle T when the pin is not centered on the target grid.

### 3-14. Initial Chart Data

a. *Grid Mission.* To determine the chart range and deflection to a target located by grid coordinates, first plot the grid coordinates of the target on the firing chart. Then determine chart range and deflection as described in paragraph 3-11.

#### ★ Example:

Known data:

BTRY B GRID: 60858 32640

TGT GRID: 623 363

BTRY AZ OF LAY: 6350

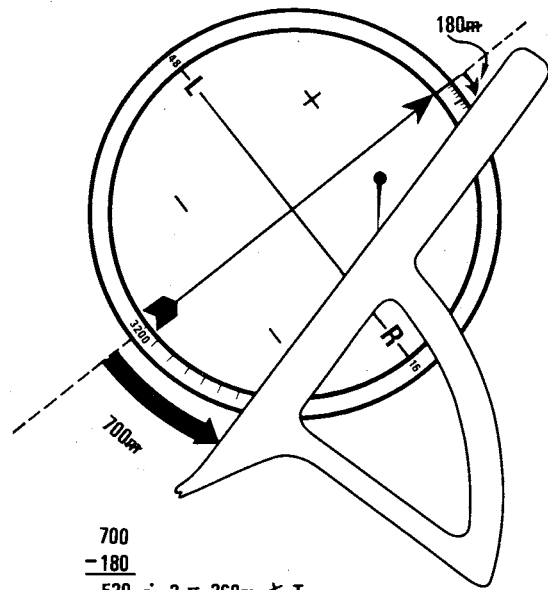


Figure 3-32. Angle T when RDP does not cross the center line.

COMMON DF: 3200

OT DIRECTION: 6200

Answers:\*

B Range: 3940

Deflection: 2768

\*Answers within 30 meters in range and 3 mils in deflection of these answers are acceptable.

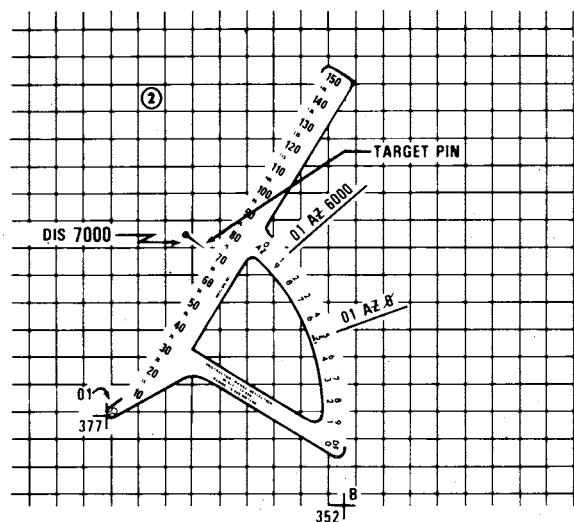


Figure 3-33. Locating the target by polar plot.

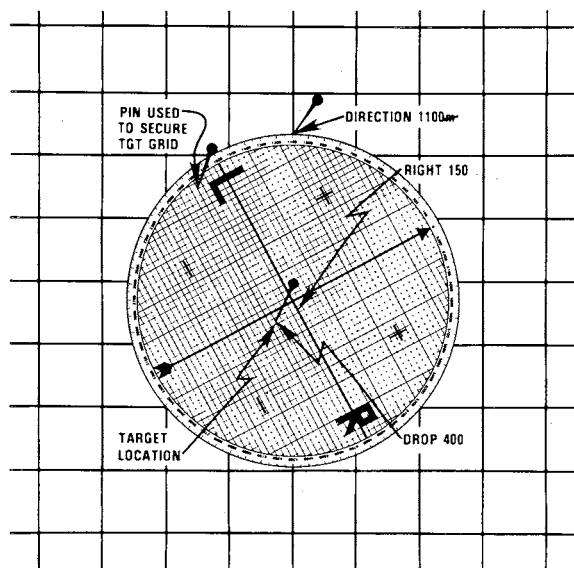


Figure 3-34. Locating the target by shift from a known point.

**b. Polar Mission.** A polar mission is a mission in which the target location is given in terms of a direction and distance from an observer. To determine chart data, the target must first be located on the firing chart. To polar plot the target location on the firing chart, use the following procedure (see fig 3-33).

(1) Place the vertex of the RDP against the pin at the OP with the arc opposite the proper azimuth index.

(2) Aline the RDP in the direction reported by the observer opposite the azimuth index. In figure 3-33, the observer (O1) reported a direction of 500.

(3) Place a pin along the left edge of the arm of the RDP at the reported distance. This is the location of the target. In figure 3-33, the observer reported a distance of 7000 meters.

(4) Place the vertex of the RDP against the pin in the battery position and determine chart range and deflection as described in paragraph 3-11.

★ **Example:**

Known data:

BTRY B GRID: 60858 32640

BTRY AZ OF LAY: 6350

COMMON DF: 3200

O1 GRID: 59748 33872

O1 REPORTS: DIRECTION 460,  
DISTANCE 3200

Answers:

B Range: 4130

Deflection: 3078

**c. Shift Mission.** A shift mission is a mission in which the target is located in reference to a known point, using OT direction, a lateral shift, a range shift, and a vertical shift. To determine chart range and deflection, first plot the target location as follows:

(1) Position the target grid on the known point and orient it on the OT direction as described in paragraph 3-12b.

(2) Plot the shift given by the observer (left or right, add or drop) on the firing chart. The pin will be in the target location. In figure 3-34, the observer reported:

DIRECTION 1100, RIGHT 150,  
DROP 400, OVER.

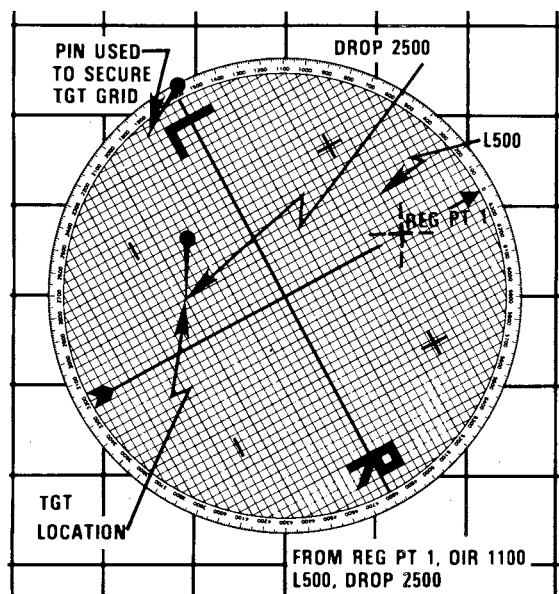


Figure 3-35. Locating the target when the initial shift plots off the target.

(3) If the shift plots the point off the target grid, reposition the target grid so that both points will fall on the target grid. Orient

the target grid in the OT direction and plot the shift (fig 3-35).

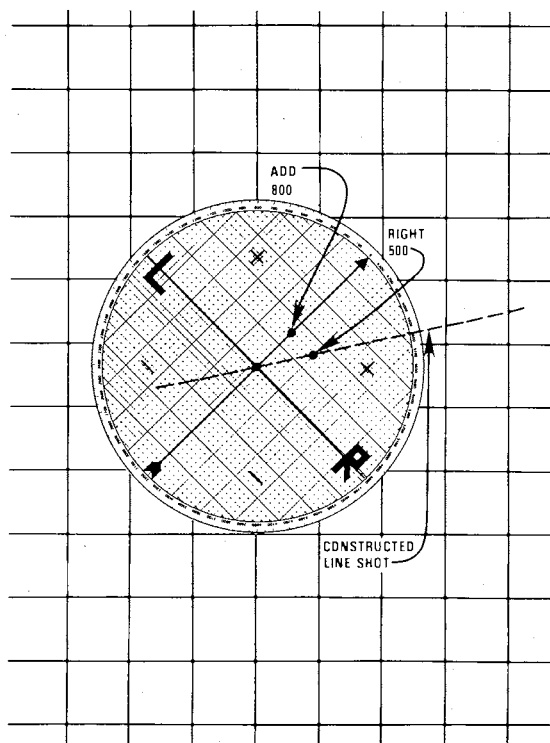


Figure 3-36. Observer's initial correction.

(4) The chart range and deflection to the target location may now be determined as described in paragraph 3-11.

★ **Example:**

Known data:

BTRY GRID: 61321 32489

REG PT 1 GRID: 60553 37465

BTRY AZ OF LAY: 6350

COMMON DF: 3200

**SHIFT DATA: SHIFT REGISTRATION POINT 1, DIRECTION 260, RIGHT 1100, ADD 1000**

Answers:

Range: 5740

Deflection: 3051

### 3-15. Subsequent Corrections

a. Once the chart operator has determined chart range and deflection, he positions and orients the target grid as described in paragraph 3-12. Angle T is then determined. Subsequent observer corrections are plotted in the same manner as in plotting the shift from a known point. Once the observer's correction is plotted, a new chart range and deflection are determined. Angle T is not determined for subsequent corrections unless it appears that the target grid is misoriented (see paragraph *b* below). The target grid is not repositioned unless subsequent corrections are so large that they cannot be plotted.

b. If it appears the OT direction sent by the observer is incorrect, the observer should be contacted for verification. If the observer cannot send a correct OT direction, the following method to correct the direction should be used:

(1) In figure 3-36, the observer's first correction is **ADD 800** (a line spotting). The chart operator plots the correction, and a round is fired at the new data.

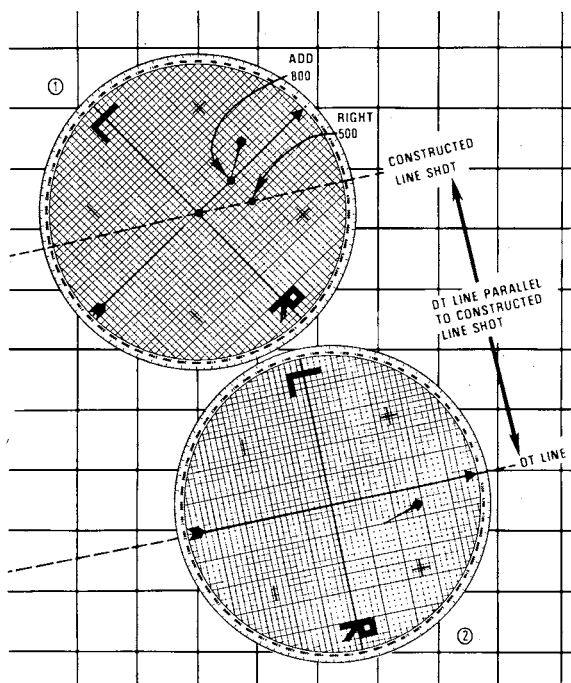


Figure 3-37. Correcting a misoriented target grid.

(2) The observer's next correction of **RIGHT 500** indicates an incorrect direction. The chart operator plots the correction and notes the constructed line shot (fig 3-37).

(3) While a round is fired with this data, the chart operator rotates the target grid

(without removing the pin) until the arrow is parallel to the constructed line shot. The target grid is now oriented in the correct direction.

(4) This procedure should be used only if the observer is using the OT line to adjust.

## Section IV. CHART VERIFICATION

### 3-16. FADAC to Manual

The M18 gun direction computer (FADAC) calculates range, distance, direction of fire, and other geometric data when the required battery and target information is input. The mathematically accurate data calculated by FADAC can be used to check the accuracy of the manual firing chart by comparing FADAC ranges and directions with those determined from the firing chart. The accuracy requirements are the same as in paragraph 3-17.

### 3-17. Manual to Manual

a. One chart will differ slightly from any other due to small differences in construction caused by human limitations in reading the graphical equipment. In recognition of these differences, the following tolerances between charts are allowed:

Range: 30 meters

Deflection: 3 mils

★ To check the accuracy of two or more charts, the same grid intersection is plotted on all charts and range and deflection to that point from the same battery on all charts are determined. If all ranges agree within 30 meters and all deflections agree within 3 mils, the charts are accurate. If not, all charts must be checked for errors.

b. Sufficient points should be checked in the battery zone of operations to insure accuracy. For example, an error in plotting the battery location on one chart could compensate for an error in construction of the deflection index on the other chart. Checking at least two points would reveal the error and should be done as a matter of unit SOP.



# CHAPTER 4

## FIRING DATA

### Section I. ELEMENTS OF FIRING DATA

The data determined from the firing chart must be converted to settings that can be placed on the weapon and ammunition. Firing data is normally computed in the fire direction center. Firing data consists of the charge, fuze setting (when applicable), deflection, and quadrant elevation to be fired.

#### 4-1. Charge

The amount of propellant to be fired with semifixed or separate-loading artillery ammunition can be varied by use of propellant increments called charges. The propellant is packaged in numbered increments so that the amount of propellant to be fired can be reduced to a smaller number of increments than is contained in the complete propellant. By announcing a certain charge (increment) number, the cannoneers will "cut" or reduce the propellant so that only the announced charge (increment) number and all lower numbered increments remain.

#### 4-2. Fuze Setting

When a projectile with a mechanical time or proximity fuze is fired, the computer will determine a fuze setting to be set on the fuze to cause it to function at the desired point along the trajectory. The fuze setting is a function of elevation (el) plus the complementary angle

of site (CAS or comp site). When the complementary angle of site is small (vertical interval less than or equal to 100 meters), the fuze setting may be considered a function of elevation alone.

a. The fuze setting corresponding to the elevation (or elevation plus comp site) for time fuze and proximity fuze may be determined from the tabular firing tables, graphical firing tables, or the M18 (FADAC) computer.

b. The fuze settings are announced as **FUZE TIME, 17.6** or **FUZE VT, 17.0**.

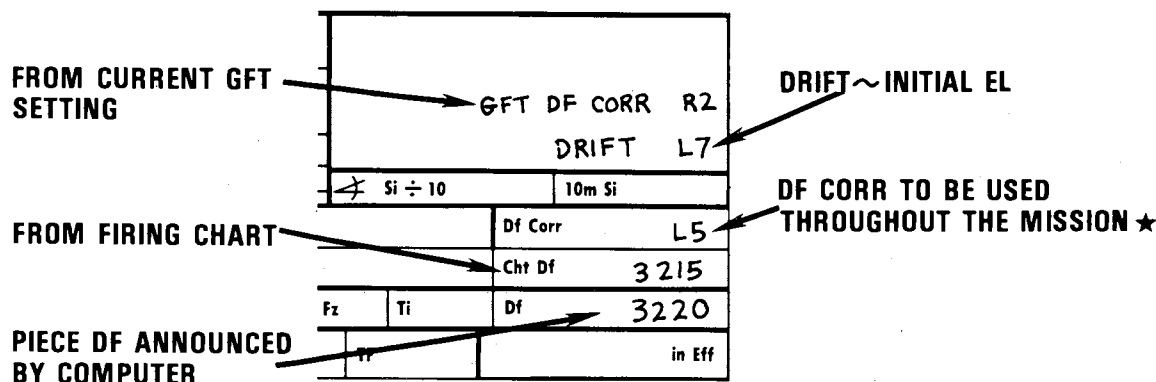
#### 4-3. Deflection

The deflection to be fired is the piece deflection. The computer determines and announces the piece deflection to the guns.

a. Piece deflection is computed by applying the deflection correction to the announced chart deflection by using the LARS rule (LEFT, ADD; RIGHT, SUBTRACT).

b. The deflection correction is determined by adding the GFT deflection correction to the drift corresponding to the initial elevation. See figure 4-1.

c. The piece deflection would be announced as **DEFLECTION 3220**.



## ★ LOW ANGLE FIRE ONLY

Figure 4-1. Determination of the deflection correction.

## 4-4. Quadrant Elevation

Given a certain charge, elevation is the vertical angle measured from the base of the trajectory at the muzzle to the extension of the center axis of the tube that is required to achieve a prescribed range under standard conditions. The elevation can be determined from tabular or graphical firing tables.

a. In table F of the tabular firing tables, ranges are listed every 100 meters in column 1 and the elevations required to achieve those ranges under standard conditions are listed to the tenth of a mil in column 2. Elevations corresponding to ranges between the listed ranges can be determined by interpolation.

b. On the GFTs and the GFT fans, the elevation required to achieve a prescribed

range under standard conditions can be read from the elevation scale. The manufacturer's hairline (MHL) on the cursor is placed over the range on the range scale and the elevation is read under the MHL on the elevation scale.

c. Range (elevation) and direction (deflection) are the two basic elements of data needed to point a piece and cause the projectile (trajectory) to pass through the target (level point). If the target or desired point of burst is at an altitude different from that of the piece, another element of firing data, called site, is required. Site is combined with elevation to cause the trajectory to pass through a target not at the level point (fig 4-2). Site usually is computed in the fire direction center by the vertical control operator.

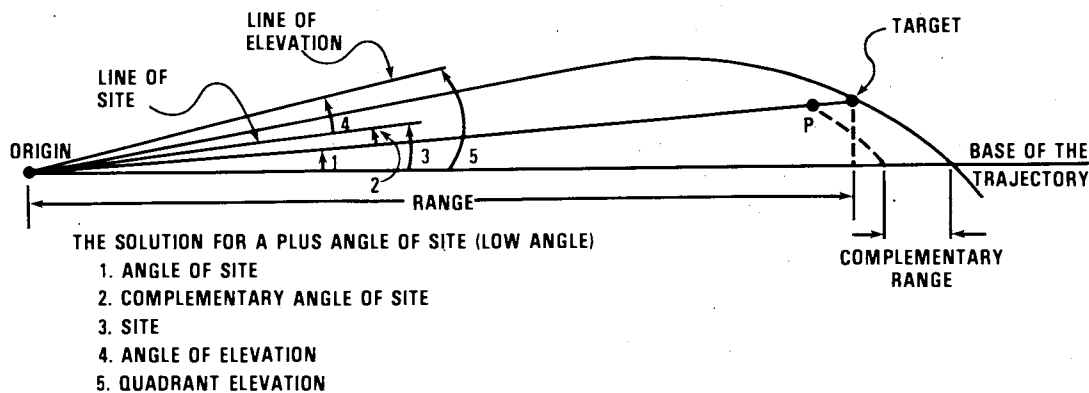


Figure 4-2. Trajectory to a target not at a level point.

d. Quadrant elevation is the algebraic sum of site and the angle of elevation. Quadrant elevation is the smaller angle at the origin in a vertical plane from the base of the trajectory to the line of elevation. Quadrant

elevation is the angle through which the tube ★ of the piece must be elevated from the base of the trajectory to cause the trajectory to pass through the target. The quadrant elevation would be announced as: **QUADRANT 320.**

## Section II. GRAPHICAL FIRING TABLES

The current tabular firing tables (TFT) for each cannon constitute the basic source of ballistic data for that cannon. The tabular firing tables are based on actual firings of the piece and its ammunition under, or correlated to, a set of conditions defined and accepted as standard. Firing data can be determined from the TFT as delineated in the introduction to each TFT; however, this is a time-consuming process. Graphical firing tables were derived from the TFT and provide a simple means of quickly determining firing data. Where there are overlapping green bag and white bag charges, the GFT is for green bag.

### 4-5. Description of Low Angle GFT (fig 4-3)

The elevation and fuze setting can be read directly from the graphical firing table. Each graphical firing table consists of one or more rules and a cursor, which slides on each rule. A fine hairline is engraved on the underside

★ of the cursor and serves as the index for reading data. The hairline is perpendicular to the scales. The hairline is called the manufacturer's hairline. Normally, both sides of the GFT are used, with data for a specific charge on each side.

a. *Scales on the GFT.* The scales on each rule are drawn at a slant to the base, angling from upper left to lower right. The scales appearing on the rule, from top to bottom, are as follows:

(1) *ICM scale.* On all new GFTs, an ICM (improved conventional munitions) scale is located above the HE (high explosive) scales. It consists of a quadrant elevation (QE) scale and a fuze setting scale for determining ICM firing data. The QE scale is graduated in mils and the fuze setting scale to the nearest 0.1 fuze setting increment. This scale is applicable only for the ICM model number at the left end of the scale.

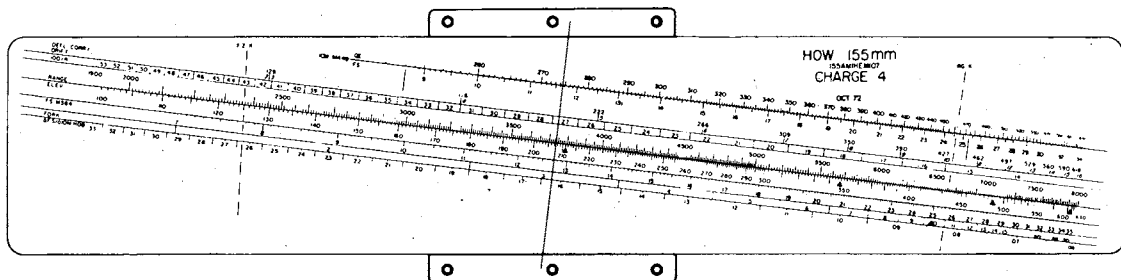
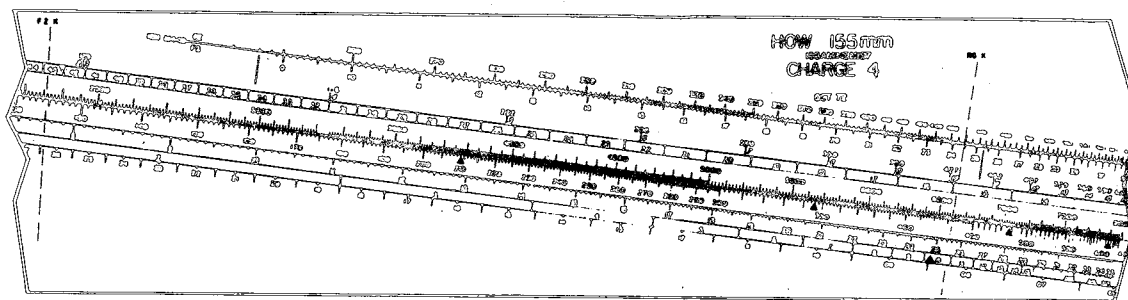


Figure 4-3. Low angle GFT.



(2) *Drift scale.* The drift scale, which is printed in black, gives the projectile drift in mils. Since the projectile drifts to the right, drift corrections are made to the left. Each elevation at which drift changes is printed in red. Artillery expression would be used to determine the value of drift at these red elevations. For example, for the M109A1 charge 4 GB, at elevation 309, the drift correction changes from L6 to L7. At elevation 309, the drift correction is L6. Artillery expression will be used on any scale where the value read is exactly on a line.

★ (3) *100/R scale.* The 100/R scale gives the number of mils necessary to shift the point of burst laterally or vertically 100 meters for a given range. The numbers on this scale are printed in red. This scale is based on the mil relation,  $\mu = W/R$ .

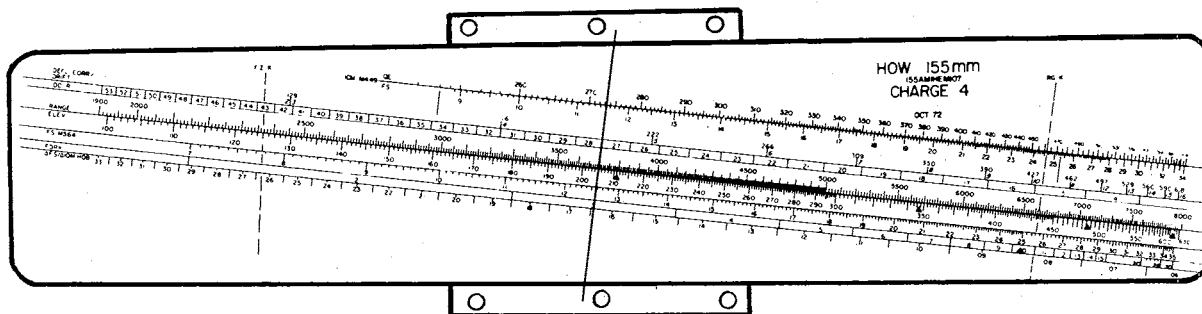
(4) *Range scale.* The range scale is the basic scale and all other scales are plotted with reference to it. Range is expressed logarithmically in meters and varies for each charge. The range scale is developed to give as large a range spread as possible and still permit graduations large enough for accurate readings. Range is read to the nearest 10 meters.

(5) *Elevation scale.* The elevation scale is graduated in mils; elevation increases from left to right and is read to the nearest 1 mil. The numbers on this scale are printed in black and red. The red numbers denote the elevations that are within range transfer limits for a one-plot GFT setting. For a one-plot GFT setting, a registration point or met check gagepoint, whose range is between the leftmost and rightmost red elevation numbers, is selected.

(6) *Fuze setting scale.* The fuze setting scale gives the fuze setting for the M564 fuze and is read to the nearest 0.1 fuze setting increment. It is also used to determine time of flight and VT fuze setting.

(7) *Fork scale.* The fork scale is graduated in mils to show the change in elevation necessary to move the mean point of impact four range probable errors. The numbers on this scale are printed in red.

(8) *Change to fuze setting for a 10-meter change in height of burst scale ( $\Delta FS/\Delta 10M$  HOB).* The change to fuze setting necessary for a 10-meter change in height of burst (HOB) scale is graduated in 0.01 increments and is read to the nearest 0.01 increment. This scale indicates the amount of correction that must be applied to the M564 fuze setting to



raise or lower the height of burst 10 meters along the trajectory.

(9) *Met check gagepoints.* Above the fuze setting line are red triangular gagepoints. The apex of each triangle points at the quadrant elevation that, under standard conditions, results in the maximum ordinate of the trajectory passing through a whole line number of a met message. The ranges and quadrant elevation at the met check gagepoints are preferred for met + VE computations and deriving GFT settings.

(10) *Height of burst probable error gagepoints.* Above the fork scale is a red right-triangular gagepoint. This gagepoint indicates the range and fuze setting at which the probable error in height of burst is 15 meters. Larger height of burst dispersion must be expected when time fuze is used with a particular charge at ranges exceeding that indicated by the gagepoint. Some charges have two triangular gagepoints. The one on the left indicates the range at which the probable error in height of burst for the next lower charge is 15 meters.

(11) *Range probable error gagepoint.* Above the  $\Delta$ FS/  $\Delta$ 10M HOB scale is a black triangular gagepoint. This gagepoint indicates the range at which the range probable error (PER) is 25 meters.

(12) *Range K line.* The range K line is a broken black line near the right edge of the rule. The angle that the range K line makes with the scales geometrically portrays the predicted rate at which range K varies with range. An elevation gageline drawn parallel to the range K line provides elevations that vary at the same predicted rate as does range K.

(13) *Fuze K line.* The fuze K line is a broken black line near the left edge of the rule. The angle that the fuze K line makes with the scales geometrically portrays the predicted rate at which fuze K varies with range. A time gageline drawn parallel to the fuze K line provides fuze settings that vary at the same predicted rate as does fuze K.

*b. Firing Data (No GFT Setting).* The procedure for determining the elevation and fuze setting with the graphical firing table when no corrections (no GFT setting) are known is as follows:

(1) Place the hairline over the measured chart range.

(2) Read the elevation under the hairline from the elevation scale.

(3) Read the fuze setting (M564) under the hairline from the fuze setting scale.

(4) When VT fuzes are used and the source of data is graphical equipment, the fuze setting for the VT fuze is obtained from the M564 fuze setting scale corresponding to the elevation to be fired. The time of flight and the fuze setting for fuze M564 will seldom differ by more than 0.2. If the fuze setting to the target is not a whole number, the next lower whole number is set on the VT fuze. For example, if the M564 fuze setting corresponding to the elevation to be fired is 20.6, the fuze setting for the VT fuze is announced as: **FUZE VT 20.0**. If the observer reports that VT fuzes are bursting on impact, the fuze setting for the VT fuze is decreased by 1.0.

**Note.** The M728 VT fuze desired HOB is 7 meters and is often misspotted as graze.

*c. Firing Data (With GFT Setting).* Under normal circumstances, FDC personnel will know or can approximate the corrections for nonstandard conditions. These corrections can be applied to the GFT using a GFT setting. The construction of the GFT setting and the determination of firing data using it are discussed in paragraphs 4-6 and 4-7, respectively.

#### 4-6. Construction of GFT Settings

a. Corrections for nonstandard conditions can be computed from registrations, met + VE techniques, or inferred from FADAC, and are usually known in the FDC. For use with the GFT, these corrections take the form of a GFT setting. The relationship between the MHL, elevation gageline, and time gageline corrects for the current nonstandard conditions.

b. A registration has just been completed in Battery B (M109A1) and the following GFT setting incorporates the corrections for nonstandard conditions determined by that registration:

GFT B: Chg 4, Lot XY, Rg 5480, El 354,  
Ti 20.5

Tot df corr: L5                      GFT df corr: R3

A one-plot GFT setting is constructed when one set of corrections for nonstandard

conditions are known. If two sets of corrections are known, a two-plot GFT setting can be constructed. The following steps will be used to place the above one-plot GFT setting on Battery B's CHG 4, 155-AM-1, GFT.

(1) Slide the cursor until the MHL is exactly over the GFT range of 5480 meters on the range scale.

(2) Place a dot (using a soft lead pencil) on the cursor at the GFT elevation of 354 mils along the elevation scale.

(3) Place a second dot on the cursor at the GFT time of 20.5 fuze setting increments along the M564 fuze setting scale (fig 4-4).

(4) Slide the cursor until the dot placed at elevation 354 is exactly centered over the RG K line. With a straightedge, draw a thin line (preferably with a soft lead pencil) through the dot and parallel to the RG K line. Label this line EL.

(5) Slide the cursor until the dot placed at time 20.5 is exactly centered over the FZ K line. With a straightedge draw a thin line (preferably with a soft lead pencil) through the dot and parallel to the FZ K line. Label this line TI.

(6) To insure that the newly constructed elevation and time gages are accurate, slide the cursor until the GFT range of 5480

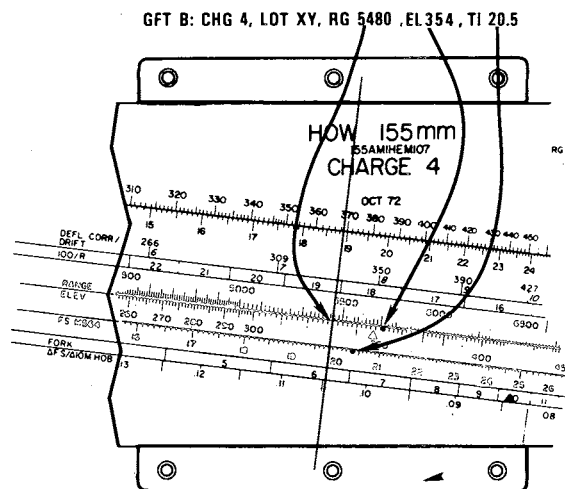


Figure 4-4. Construction of GFT setting.

meters is again under the MHL. Read the value for elevation where the elevation gageline crosses the elevation scale. Check the accuracy of the time gageline in the same manner. The elevation and time gagelines may be color coded for easier identification.

(7) Place the value of the total deflection correction on the upper left portion of the cursor with a circle around it. Place the value of the GFT deflection correction on the upper right portion of the cursor.

#### 4-7. Determination of Firing Data

Determination of firing data with no GFT setting has been discussed in paragraph 4-5b. However, usually a GFT setting will be known and firing data will be determined from a GFT with a GFT setting applied.

##### a. Reading GFT Scales With GFT Setting.

(1) *ICM scale.* Once the HE quadrant elevation is known, slide the cursor until the MHL is over the value of the HE quadrant elevation on the elevation scale. Read the ICM quadrant on the ICMQE scale under the MHL. To determine the ICM fuze setting, place the MHL over the M564 fuze setting and read the ICM time under the MHL on the ICM fuze setting scale.

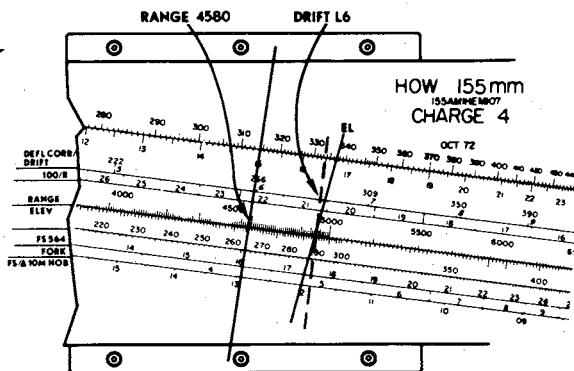


Figure 4-5. The drift scale.

(2) *Drift scale.* Drift is a function of elevation, but cannot be read under the elevation gageline. Drift is read on the drift scale under an imaginary line which is parallel to the MHL and crosses the elevation scale at the same point as the elevation gageline (fig 4-5). (The following illustrations use GFT setting shown in paragraph 4-6.)

★ (3) *100/R scale.* 100/R is a function of range and is read under the MHL. Since it is based on the mil relation, 100/R is unaffected by corrections for nonstandard conditions, charge, projectile, or caliber (fig 4-6).

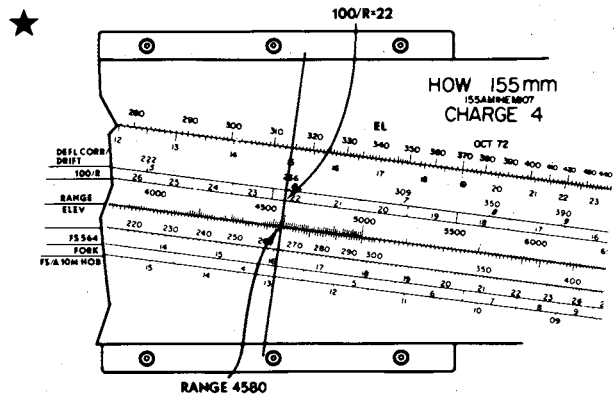


Figure 4-6. 100/R scale.

(4) *Range scale.* The range scale is the base scale of the GFT and is always read under the MHL.

(5) *Elevation scale.* Elevation is read under the constructed elevation gageline where it crosses the elevation scale (fig 4-7).

(6) *Fuze setting (M564) scale.* The time to be set on the M564 fuze is read under the constructed time gageline where it crosses the fuze setting scale.

(7) *Fork scale.* The fork scale gives the number of mils necessary to change the range an equivalent of four probable errors in range. It is no longer used in fire direction.

(8)  *$\Delta FS/\Delta 10M HOB$  scale.*  $\Delta FS$  is a function of fuze setting but cannot be read under the time gageline.  $\Delta FS$  is read on the

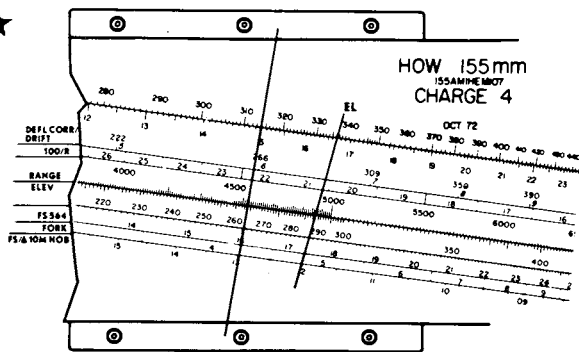


Figure 4-7. Elevation scale.

$\Delta$ FS/ $\Delta$ 10M HOB scale under an imaginary line that is parallel to the MHL and crosses the fuze setting scale at the same point as the time gageline (fig 4-8).

(9) *VT fuze setting or time of flight (TOF).* Time of flight is a function of elevation, but cannot be read from the elevation gageline. Time of flight (or VT fuze setting) is read on the M564 fuze setting scale under an imaginary line that is parallel to the MHL and crosses the elevation scale at the same point as the elevation gageline. Once a value has been read from the M564 fuze

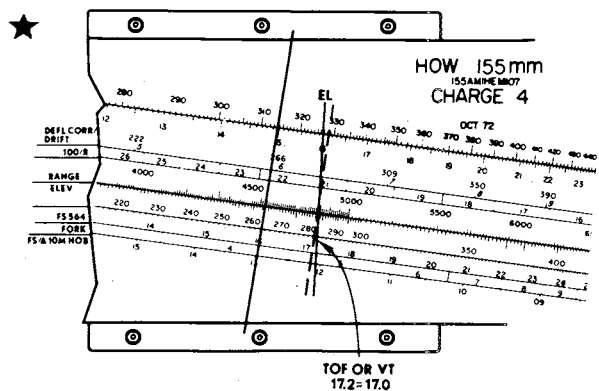


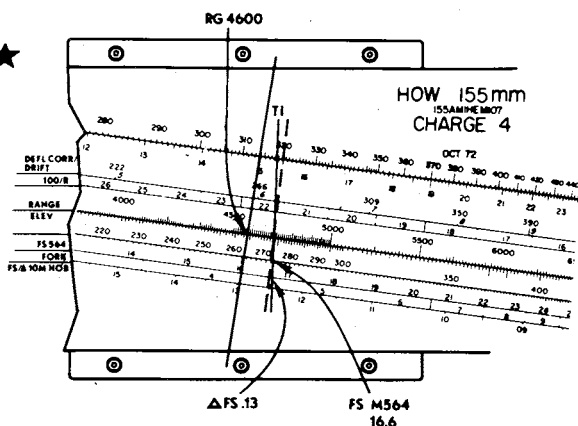
Figure 4-9. Time of flight or VT fuze setting.

*b. Firing Data.* The three elements of firing data—fuze setting, deflection, and quadrant elevation—can now be determined from the GFT.

(1) The fuze setting for the M564 fuze is read under the time gageline on the FS M564 scale, and the fuze setting for the VT fuze is determined as discussed in paragraph a(9) above.

(2) The deflection is determined by combining the deflection correction with the chart deflection as discussed in paragraph 4-3.

(3) The quadrant elevation is the combination of elevation and site. The elevation is read under the elevation gageline

Figure 4-8.  $\Delta$ FS/ $\Delta$ 10M HOB scale.



on the elevation scale. Once site has been computed and announced by the VCO, the

computer will apply it to elevation and announce QE to the guns.

## Section III. GFT FAN

The GFT fan is available in all 105-mm and 155-mm units. The GFT fan is currently the most rapid means of determining initial firing data because all basic data can be read directly from one instrument. Normally, to increase responsiveness, the firing data for the initial round will come from the GFT fan with subsequent firing data determined by FADAC.

with the charge at the top and bottom to help prevent using the wrong charge to determine data.

*c. Elevation Scale.* Along the right edge of each charge ballistic scale is the elevation scale. This scale is a logarithmic scale just as is found on the GFT; however, it is graduated every 5 mils and labeled every 50 mils.

### 4-8. Description of GFT Fan

The ballistic template, which is placed on the arm of the RDP, has a series of scales for each of the overlapping charges. The scales for each charge are similar to those found on the GFT for that particular charge. However, the range spectrum found on the GFT fan is less than that found on the GFT. The optimum ranges for a particular charge are portrayed on the GFT fan. Once a target has been plotted on the firing chart, the chart operator moves the GFT fan until the plotting pin is centered adjacent to the edge of the MHL on the cursor. He then is ready to announce firing data using the scales (fig 4-10).

*a. Range Scale.* The range scale is the base scale of the GFT fan. It runs along the left edge of the ballistic template and should coincide exactly with the range scale on the RDP underneath. It is graduated the same as the RDP and range can be read to an accuracy of 10 meters under the MHL on the cursor.

*b. Charge.* Normally, a target will plot so that more than one charge can be used to attack the target. Once a charge has been selected, the chart operator must insure that he does not read subsequent data from the wrong charge scale. The scales are labeled

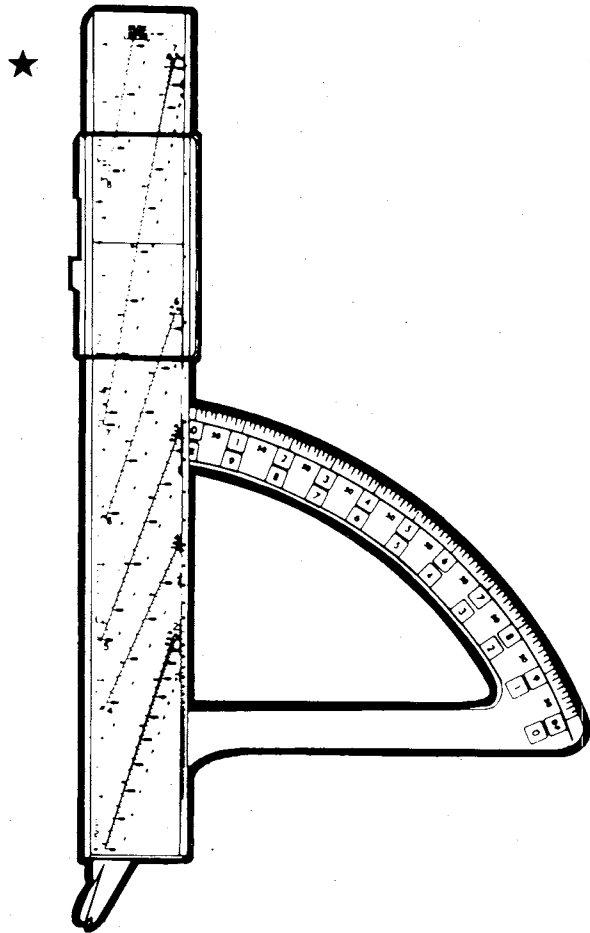


Figure 4-10. The GFT fan.

Elevation can be visually interpolated to the nearest 1 mil.

d. *Fuze Setting Scale (M564).* Along the left edge of each charge ballistic scale is the M564 fuze setting scale. This logarithmic scale is graduated every whole fuze setting increment and labeled every five increments. Fuze setting can be interpolated visually to the nearest 0.1 fuze setting increment.

e. *Drift Scale.* The drift scale is to the right of each charge's elevation scale. It is read exactly as the drift scale on the GFT is read.

f. *100/R Scale.* The 100/R scale is along the right edge of the ballistic template. It is read exactly as the 100/R scale on the GFT is read.

★ g.  *$\Delta FS/\Delta 10M$  HOB Scale.* This scale is not found on the GFT fan. The  $\Delta FS/\Delta 10M$  HOB scale on the appropriate GFT or TFT must be used to adjust the height of burst for time fuze.

#### 4-9. Construction of GFT Setting

★ Since range K and fuze K lines are not found on the GFT fan, it is preferred to use a two-plot or multiplot GFT setting (see paragraph 5-36 for multiplot GFT settings). If only one plot is available, place the elevation and time gagelines parallel to the MHL. Usually two-plot GFT settings will be derived by FADAC for the standard charge. However, it is possible to have two-plot GFT settings for various charges, so the chart operator must be careful. If several cursors are available, it is suggested that only one GFT setting for a particular charge be placed on each cursor.

a. In the example, a registration has been conducted by Battery C (M109A1) and FADAC was used to derive a second plot. The following GFT settings are determined:

GFT C: Chg 4, Lot RY, Rg 4450, El 270,  
Ti 15.9

Tot df corr: L1 GFT df corr: R5

GFT C: Chg 4, Lot RY, Rg 5660, El 370,  
Ti 21.4

Tot df corr: L3 GFT df corr: R5

b. The following steps will be used to place a two-plot GFT setting on Battery C's 155-AM-1 GFT fan.

(1) Slide the cursor until the MHL is exactly over the first GFT range of 4450 meters on the range scale.

(2) Place a dot (using a soft lead pencil) on the cursor at the first GFT elevation of 270 mils along the charge 4 elevation scale.

(3) Place a second dot on the cursor at the first GFT time of 15.9 fuze setting increments along the CHG 4, M564 fuze setting scale.

(4) Repeat the steps in (1) through (3) with the second GFT setting.

(5) The cursor now has four dots on it: two elevation dots and two time dots. With a straightedge, draw a line through the two elevation dots. Do the same with the two time dots. These lines represent the elevation gageline and time gageline. Label them EL and TI, respectively (fig 4-11).

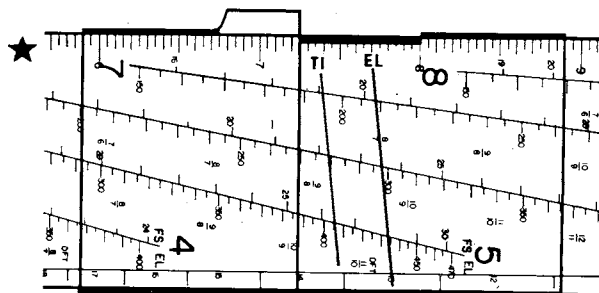


Figure 4-11. Elevation and time gagelines on the GFT fan.

(6) Just as an average elevation gageline and an average time gageline have been determined, an average deflection correction is determined.

(a) The total deflection correction for the first GFT setting was L1. The total

deflection correction for the second GFT setting was L3. The average total deflection correction is  $L2\left(\frac{L1 + L3}{2} = \frac{L4}{2} = L2\right)$ .

(b) The GFT deflection correction for the first GFT setting was R5. The GFT deflection correction for the second GFT setting was R5. The average GFT deflection correction is  $R5\left(\frac{R5 + R5}{2} = \frac{R10}{2} = R5\right)$ .

(c) Place the value of the average total deflection correction (L2) on the upper left portion of the cursor with a circle around it. Place the value of the average GFT deflection correction (R5) on the upper right portion of the cursor. The average total deflection correction would be used for suppressive fires such as immediate suppression, immediate smoke, or any time that responsiveness is more important than accuracy. The average GFT deflection correction would be combined with drift to calculate the deflection correction to be used with other missions. Similar procedures would be used to place the two-plot GFT setting on the GFT.

#### 4-10. Determination of Firing Data

The GFT fan is the most rapid means of determining firing data, and units that have it will most likely use it to determine data for

the initial round. When a FADAC derived two-plot GFT setting is placed on the GFT fan, there is minimal loss in accuracy with a tremendous gain in speed.

##### a. Reading the Scales.

(1) *Range scale.* Range on the range scale is read in the same manner as before, under the MHL.

(2) *Charge.* Charge is determined as before.

★ (3) *Elevation scale.* Elevation is read under the elevation gageline where it crosses the elevation scale for the appropriate charge.

(4) *Fuze setting scale (M564).* M564 fuze setting is read under the time gageline where it crosses the fuze setting scale for the appropriate charge.

(5) *Drift scale.* As with the GFT, drift is read on the drift scale under an imaginary line that is parallel to the MHL and crosses the elevation scale at the same point as the elevation gageline.

(6) *100/R scale.* 100/R is read as before under the MHL.

(7) *Time of flight (VT fuze setting).* Time of flight (or VT fuze setting) is read on the

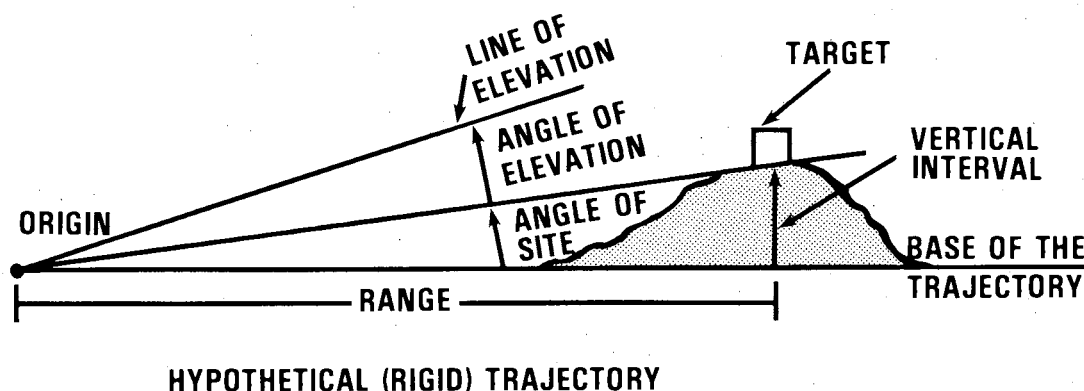


Figure 4-12. Effect of angle of site.

M564 fuze setting scale at the point where the elevation gageline crosses the elevation scale. Once a value is determined, the tenths are dropped as before.

*b. Firing Data.* The GFT fan can be used by its operator to determine all initial firing data.

(1) *Charge.* Once the target is plotted and the GFT fan alined with it, the operator can announce the optimum charge for the mission.

(2) *Fuze setting.* If a time or proximity fuze was designated in the fire order, the fuze setting for M564 would be determined as discussed in paragraph *a*(4) above, and VT fuze setting would be determined as discussed in paragraph *a*(7) above.

(3) *Deflection.* Two brief mental computations are required of the GFT fan operator in order to determine deflection.

(a) First, the operator must determine the deflection correction by mentally applying the average GFT deflection correction to drift (para *a*(5) above). Average GFT df corr (R5) + drift (L8) = df corr (L3).

(b) Second, the operator must mentally apply this deflection correction to the chart deflection he reads from the arc of the RDP. This is piece deflection and is announced to the computer. df corr (L3) + cht df (3052) = pc df (3055)

(4) *Quadrant elevation.* A single mental computation is required of the GFT fan operator to determine QE. The operator reads elevation from the GFT fan and mentally

applies site to it. He then announces quadrant elevation. The site used may be an average site or one computed with the GST. el (372) + site (+5) = QE (377)

(5) 20/R. If a time or proximity fuze (M514 or M513 only) is used, 20/R must be added to ground site. This would be done mentally by the GFT fan operator. Ground site (+5) + 20/R (+4) = Total site (+9)

*Note.* Due to low airburst obtained with M728 VT fuze (7 meters) 20/R is not added.

*c. Suppressive Fires.* Due to the urgency required by suppressive fires, the GFT fan operator uses certain shortcut procedures.

(1) Normally, VT fuzes are fired at a predetermined safe fuze setting; therefore, the fuzes are preset and a VT fuze setting need not be determined.

★ (2) 20/R is ignored; therefore, the GFT fan operator does not have to consider determining 100/R and 20/R.

(3) The GFT fan operator will determine deflection by applying the average total deflection correction to the chart deflection. This eliminates one mental computation and speeds up the mission. Avg tot df corr (L2) + cht df (3310) = pc df (3312)

(4) The GFT fan operator will use average site if available. The elevation read from the GFT fan will be combined with average site and announced as QE. If no average site is available, then site will be ignored and the elevation read will be announced as QE. Elev (280) + Avg site (+3) = QE (283)

## Section IV. SITE

As discussed earlier (para 4-4c), site is computed to correct for situations where the target is not at the same altitude as the battery. To understand site, a brief description of the trajectory is necessary.

### 4-11. Initial Elements of the Trajectory

*a. Vertical Interval.* The vertical interval

(VI) is the difference in altitude between the battery or observation post and the target or point of burst. The VCO determines the vertical interval by algebraically subtracting the altitude of the battery or observation post from the altitude of the target or point of burst. The vertical interval is determined to the nearest meter and is a signed value.

*b. Angle of Site.* The angle of site is the smaller angle in a vertical plane from the base of the trajectory to the straight line joining the origin and the target. The angle of site is plus when the target is above the base of the trajectory and minus when the target is below the base of the trajectory. The angle of site compensates for the vertical interval (fig 4-12).

*c. Complementary Angle of Site.* The complementary angle of site is an angle that is algebraically added to the angle of site to compensate for the changing shape of the trajectory. The trajectory may be rotated vertically about the origin an amount equal to small angles of site without significantly affecting its shape. When large angles of site or the longer ranges for any one charge are involved, significant error is introduced because the shape of the trajectory changes. If comp site is not added to angle of site in low angle fire on a target at an altitude higher than the battery, the trajectory will pass under the target. The trajectory will pass over a target at an altitude lower than the battery. The value and sign of comp site depend on the angle of site, the range, the shape of the trajectory (low or high angle fire), and the muzzle velocity. The range corresponding to comp site is called complementary range (fig 4-13).

*d. Site.* Site is the algebraic sum of the angle of site and the complementary angle of site.

*e. Line of Site.* The line of site is the straight line constructed from the origin at the angular distance from the base of the trajectory equal to site.

*f. Angle of Elevation.* The angle of elevation is the smaller angle at the origin in a vertical plane from the line of site to the line of elevation.

#### 4-12. Computation of Site Using the Tabular Firing Table (TFT)

##### *a. Altitude of Target.*

(1) Determination of the target (or point of burst) altitude is the first step in obtaining site. The altitudes of the batteries, surveyed observation posts, and registration points in the target area usually are provided by the survey section. The altitude of an observer whose position is to be plotted on the firing chart is often determined from a contour map. The vertical control operator obtains or determines the altitude of the target to be engaged in one of the following ways:

(a) The altitude may have been determined by survey and given to FDC.

(b) The call for fire may contain the altitude (usually the case when another unit determines the target location).

(c) The call for fire may locate the target as a shift from a known point or polar plot and the altitude is determined as in (2) below.

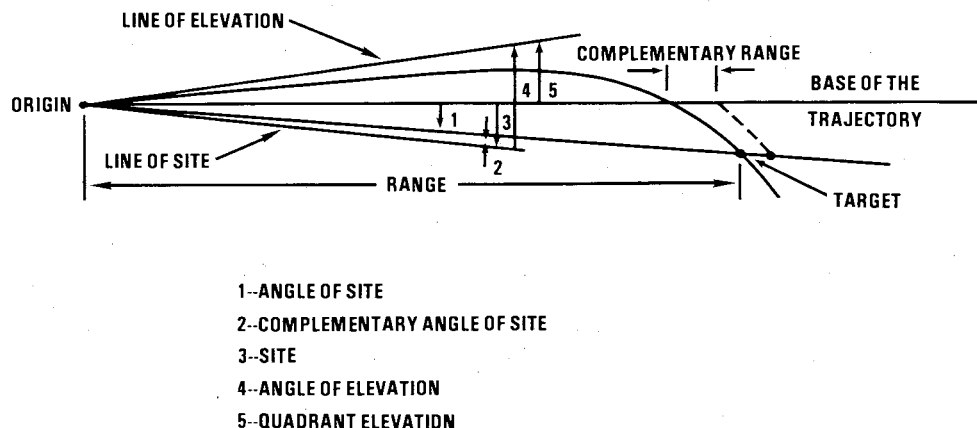


Figure 4-13. Complementary range.

(d) The target altitude may be determined from a map when the observer has located the target by grid coordinates. Altitude is determined to the nearest one-half contour interval. Altitudes and contour intervals on many maps are still given in feet. Such altitudes must be converted to meters:

$$\text{FEET} \times 0.3048 = \text{METERS}$$

(2) When the call for fire includes the location of the target as a shift from a known point or polar plot, the vertical control operator applies the vertical shift (zero, if none is specified) to the altitude of the known point to obtain the target altitude. The map altitude of the point located by the shift is disregarded. For example, an observer's call for fire includes:

SHIFT REGISTRATION POINT 1.  
DIRECTION 2500, RIGHT 200.  
ADD 400, UP 30

The UP 30 indicates that the observer estimates the target to be 30 meters higher than registration point 1. Similarly, an observer whose position is plotted on the chart may give the altitude of a target in relation to his own position. For example, the observer's altitude is 400 meters and the call for fire includes:

DIRECTION 2740, DISTANCE  
2400, DOWN 25

Therefore, the altitude of the target is 375 meters.

*b. Vertical Interval.* When the altitude of the target is determined and the altitude of the battery is known, the next step is to compute the vertical interval (difference in altitude) between the battery and the target. The altitude of the battery is always subtracted algebraically from the altitude of the target. Vertical interval (VI) is computed to 1 meter and must be expressed as plus or minus. For example, if the battery altitude is 376 meters and the target altitude is 354 meters, the VI is -22 meters (354 - 376). A vertical interval can also be computed in reference to an observation post by algebraically subtracting the altitude of the OP from the altitude of the target. If the desired point of burst is to be at an altitude

other than the target altitude, the vertical interval is computed to the burst altitude instead of the target altitude.

*c. Angle of Site and Vertical Angle.*

(1) *Angle of site.* When the vertical interval and chart range are known, the angle of site is determined by the mil relation:  $\angle = W/R$ , where  $\angle$  is the angle of site, W is the vertical interval in meters between the piece and the target or point of burst, and R is the range to the nearest 100 meters expressed in thousands (e.g., range 4060 meters is expressed as 4.1). Angle of site is computed to the nearest one-tenth mil. The angle of site is a signed value and has the same sign as the vertical interval. The angle of site is plus when the target is above the piece; it is minus when the target is below the piece.

(a) For angles of site of  $\pm 100$  mils or less, the mil relation is sufficiently accurate for the computation of angle of site or site by use of the firing tables.

(b) Angles of site greater than  $\pm 100$  mils must be computed by use of the following formula:  $\tan \angle \text{Site} = VI/R$ . See the example in paragraph 4-13.

*Example 1:*

The altitude of the battery is 397 meters. The altitude of registration point 1 is 414 meters. The chart range to registration point 1 is 4450 meters. Compute the angle of site.

Computation of vertical interval and angle of site.

|                           |                     |
|---------------------------|---------------------|
| Reg Pt 1 altitude         | 414 meters          |
| Subtract battery altitude | <u>-397 meters</u>  |
| Vertical interval         | +17 meters          |
| Angle of site = $VI/R$    | $= +17/4.4 = +3.86$ |
|                           | or +3.9 mils        |

The plus sign must be included because the altitude of the registration point is higher than that of the battery.

*Example 2:*

The altitude of target AF7821 is 451 meters. The altitude of the battery is 431 meters. The observer reports a target location:

SHIFT 821, OVER, DIRECTION  
5710, RIGHT 200, ADD 700, DOWN  
30

The chart range to the plotted target location is 4790 meters. Compute the angle of site.

Computation of target altitude:

|                                     |                    |
|-------------------------------------|--------------------|
| Target 821                          | 451 meters         |
| Subtract 30 (observer's<br>DOWN 30) | <u>- 30 meters</u> |
| Target altitude                     | 421 meters         |

Computation of vertical interval and angle of site:

|                                                          |                    |
|----------------------------------------------------------|--------------------|
| Target altitude                                          | 421 meters         |
| Subtract battery altitude                                | <u>-431 meters</u> |
| Vertical interval                                        | -10 meters         |
| Angle of site = $VI/R = -10/4.8 = -2.08$<br>or -2.1 mils |                    |

The angle of site is minus because the target altitude is lower than the battery altitude.

(2) *Vertical angle.* The vertical angle is defined as the smaller angle in a vertical plane from the horizontal to the straight line joining the observer and the target (or point of burst). The vertical angle is plus when the target is above the horizontal; it is minus when the target is below the horizontal. The vertical angle is determined by use of the mil relation:

$$\alpha = W/R$$

where  $\alpha$  is the vertical angle,  $W$  is the vertical interval in meters from the observer to the target, and  $R$  is the distance to the nearest 100 meters in thousands from the observer to the target. The vertical angle is determined to the nearest mil. The tangent function formula ( $\tan \text{ vertical angle} = VI/\text{distance}$ ) should be used when the vertical angle exceeds  $\pm 100$  mils.

*Example:*

The FDC desires to identify a target to an observer. The altitude of the OP is 578 meters; the altitude of the target is 543 meters. The distance from the OP to the target is 2650 meters. Compute the vertical angle at the OP.

Computation of vertical interval and vertical angle:

|                                                                    |                    |
|--------------------------------------------------------------------|--------------------|
| Target altitude                                                    | 543 meters         |
| Subtract OP altitude                                               | <u>-578 meters</u> |
| Vertical interval                                                  | -35 meters         |
| Vertical angle = $VI/\text{dis} = -35/2.6 = -13.45$<br>or -13 mils |                    |

(3) *Vertical interval.* The vertical interval can be computed ( $VI = \alpha R$ ) when the angle of site and range or the vertical angle and distance are known.

*Example:*

An observer desires to determine the altitude of a target. The altitude of the OP is 263 meters. The vertical angle from the OP to the target is -4 mils. The estimated distance from the OP to the target is 1600 meters. Compute the target altitude.

Computation of vertical interval and target altitude:

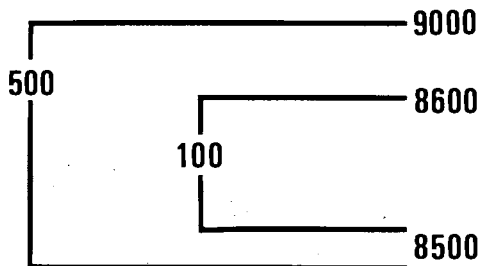
|                                     |                                     |
|-------------------------------------|-------------------------------------|
| Distance to target                  | 1.6 thousand meters                 |
| Multiplied by the<br>vertical angle | <u><math>\times(-4)</math> mils</u> |
| Vertical interval                   | -6.4 or -6 meters                   |
| OP altitude                         | 263 meters                          |
| Add vertical interval               | <u><math>+(-6)</math> meters</u>    |
| Target altitude                     | 257 meters                          |

*d. Complementary Angle of Site.*

(1) The complementary angle of site is computed by multiplying a plus (minus) angle of site times the value of the complementary angle of site for a plus (minus) 1 mil angle of site. This value is found in column 12 (or 13) of the supplementary data table (table G) of the firing table and is commonly called the comp site factor. The comp site factor must be determined by interpolation for the chart range to the nearest 100 meters. Comp site, which is computed to one-tenth mil, is a signed quantity and takes the sign of the comp site factor.

(2) A study of listed values for the comp site factor reveals that for short ranges, the comp site factor is negligible. As the range increases, the factor increases for any given

## RANGE



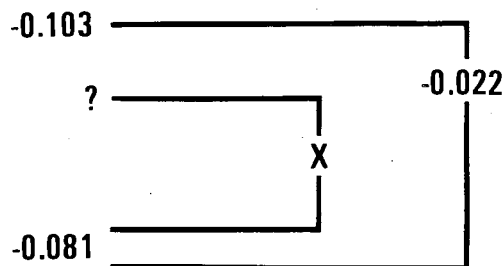
$$\frac{100}{500} = \frac{X}{-0.022}$$

COMP SITE FACTOR, RANGE 8500  
ADD VALUE OF X  
COMP SITE FACTOR, RANGE 8600

$$\begin{array}{r} -0.081 \text{ mil} \\ + (-0.004) \text{ mil} \\ \hline -0.085 \text{ mil} \end{array}$$

## COMP SITE

## FACTOR



$$X = 0.0044 \text{ or } -0.004 \text{ mil}$$

## COMPUTATION OF COMPLEMENTARY ANGLE OF SITE:

COMP SITE FACTOR  
MULTIPLIED BY ANGLE OF SITE  
COMP SITE

$$\begin{array}{r} -0.085 \text{ mil} \\ \times 1.2 \text{ mil} \\ \hline -0.1020 \text{ or } -0.1 \text{ mil} \end{array}$$

★ Figure 4-14. Interpolation for chart range 8650.

charge. Thus, at greater ranges, the comp site factor is significant even for small angles of site. The comp site factor also varies with the charge for any given range.

*Example 1:*

FT 155-AM-1, charge 4, GB, chart range 5000 meters, angle of site +7.1 mils (target above battery position). Compute the comp site.

Computation of complementary angle of site:

Comp site factor for a +1 mil angle of site, range 5000  
(col 12, p 110, FT 155-AM-1) +0.102 mil

Multiplied by angle of site

Comp site

$$\begin{array}{r} \times 7.1 \text{ mils} \\ +0.7242, \text{ or} \\ +0.7 \text{ mil} \end{array}$$

★ *Example 2:*

FT 155-AM-1, charge 6, chart range 8650 meters, angle of site -1.2 mils (target below battery position). Compute the comp site. Computation of the comp site factor for a -1 mil angle of site (col 13, p 296, FT 155-AM-1), interpolating for range 8600 (fig 4-14).

e. *Site.* Site is the algebraic sum of angle of site and comp site. Site is a signed value and is expressed to 1 mil.



**Example:**

FT 155-AM-1, charge 4, GB, battery altitude 270 meters, target altitude 301 meters, chart range 4710 meters. Compute the site.

**Computation of vertical interval:**

|                           |             |
|---------------------------|-------------|
| Target altitude           | 301 meters  |
| Subtract battery altitude | -270 meters |
| Vertical interval         | +31 meters  |

**Computation of angle of site:**

Angle of site =  $+31/4.7 = +6.6$  mils

Comp site =  $+0.1 (+6.6 \times 0.085 \text{ CSF} = 0.561 \approx 0.6 \text{ mil})$

Site =  $+7 (6.6 + 0.6 = 7.2 \approx +7)$

#### 4-13. Description of and Computations with the Graphical Site Table (GST)

The computation of site by the use of the angle of site and the complementary angle of site factor from the firing table is time consuming and is not as accurate as the GST. The graphical site table was developed to provide a quick, accurate computation of vertical angle, angle of site, and site. The GST can also be used to compute the vertical interval when the site, the charge, and the range are known, when the angle of site and the range are known, or when the vertical angle and the distance are known. The GST includes a means for converting yards to meters or meters to yards without any additional movement of the slide or cursor. Each GST is designed for a particular weapon and site computations are valid only for the weapon specified on the GST.

a. *Description of the GST (fig 4-15).* The GST consists of a base, slide, and cursor. All

GSTs developed between 1961 and 1974 include an FDC spotting table on the base behind the slide. The observer spotting column is on both ends of the slide. These have no current use.

(1) *Base.* The base is marked with the D (site and vertical interval) scale. The marking of the D scale is identical to that of the logarithmic D scale of the military slide rule. This scale is used to represent the values of vertical interval, vertical angle, angle of site, and site.

(2) *Slide.* The slide is marked with a C scale, gagepoints, and site range scales.

(a) *C scale.* The C (range) scale is identical to the logarithmic C scale of the military slide rule and is used with the D scale to perform multiplication and division. The C and D scales, along with the M gagepoint, are used for computing vertical interval, vertical angle, and angle of site.

(b) *Gagepoints.* The C scale is also marked with M (meter) and YD (yard) gagepoints. The M gagepoint multiplies the value opposite the C index by 1.0186, which gives an immediate and precise solution to the mil relation.

$$M = 1.0186 W/R$$

The use of the M gagepoint is required when the vertical interval and range are in the same unit of measure. The YD gagepoint multiplies the value opposite the M gagepoint by 0.9144, which gives an immediate solution to the formula:

$$\text{YARDS} \times 0.9144 = \text{METERS}$$

(c) *Site-range scales.* The site-range scales are used to compute site when the vertical interval and range are known or to

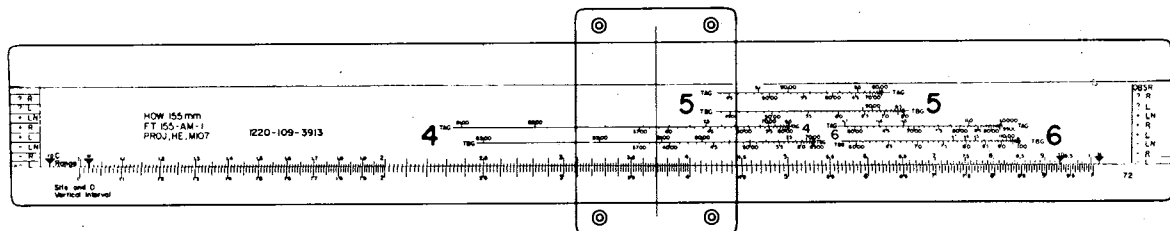


Figure 4-15. The GST.

compute the vertical interval when the site and range are known. For each charge indicated, there are two site-range scales—one in black, marked TAG (target above gun), and the other in red, marked TBG (target below gun). Each scale is placed in relation to the M gagepoint so that site is read on the D scale opposite the M gagepoint when vertical interval on the D scale is divided by range on the site-range scale. The TAG and TBG scales are constructed to include comp site and differ from one another just as the comp site factor for a plus angle of site differs from the comp site factor for a minus angle of site. The TAG scale is used when the VI or site is plus, and the TBG scale is used when the VI or site is minus. The value of site is read or placed opposite the M gagepoint.

(3) *Cursor.* The cursor has a vertical hairline and serves the same purpose as the indicator of a military slide rule; i.e., it enables the user to place or read a value on the slide opposite another value on the base.

*b. Multiplication and Division With GST.* The scales are read, and multiplication, division, and rough computation for the decimal point location are performed, in the same manner on the GST as they are on the military slide rule.

*c. Yard-Meter Conversion on GST.*

(1) *Yards to meters.* To convert yards to meters, place the M gagepoint opposite the known number of yards on the D scale and read the equivalent number of meters on the D scale opposite the YD gagepoint. For example, 2860 yards = 2620 meters.

(2) *Meters to yards.* To convert meters to yards, place the YD gagepoint opposite the known number of meters on the D scale and read the equivalent number of yards on the D scale opposite the M gagepoint. For example, 17 meters = 18.6 yards  $\approx$  19 yards.

*d. Computation of Angle of Site.* For computation of angle of site, the range is used to the nearest 10 meters and the answer is read opposite the M gagepoint to the nearest 1 mil.

(1) Move the hairline over the VI on the

vertical interval (D) scale.

(2) By moving the slide, set the range (to the nearest 10 meters) on the range (C) scale under the hairline.

(3) Read the value opposite the M gagepoint on the D scale. Determine the decimal point location by rough computation (range is in thousands; e.g., range 4780 = 5). Express the result to the nearest mil for the angle of site, which must have the same sign as that of the VI.

★ *Example (fig 4-16):*

The vertical interval is +37 meters; the range is 5460 meters. Compute the angle of site. Move the hairline over 37 on the D scale. Move the slide until 5460 on the C scale is under the hairline. Read 687 opposite the M gagepoint. Determine the decimal point location ( $37 \div 5 = 7.4$ ). The vertical interval is plus; therefore, the angle of site is  $+6.87 \approx +7$  mils.

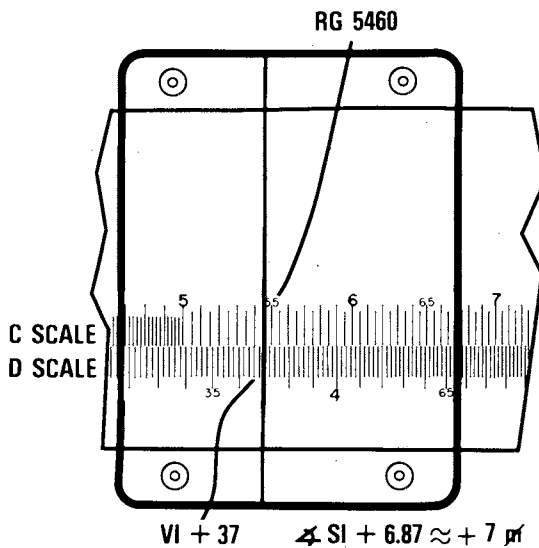


Figure 4-16. GST position for angle of site for a VI of +37 at a range of 5460 meters.

*e. Computation of Vertical Angle.* A vertical angle is computed in the same manner as an angle of site.

*f. Computation of Site.* To compute site, use the appropriate site-range scale instead of

the range (C) scale so that comp site is automatically added to angle of site.

(1) Move the hairline over the VI on the vertical interval (D) scale.

(2) By moving the slide, set the range (to the nearest 10 meters) on the appropriate site-range scale under the hairline.

(3) Read the value opposite the M gagepoint. Determine the decimal point location, express the result to the nearest mil, and use the same sign as that of the VI.

*Example (fig 4-17):*

The vertical interval is +37 meters; the range is 5480 meters; charge 4 GB, GST 155-AM-1. Compute the site. Move the hairline over 37 on the D scale. Move the slide until range 5480 on the site-range scale (chg 4, TAG) is under the hairline. Read 788 opposite the M gagepoint. Site is therefore +8 mils (+37 ÷ 5 rough division).

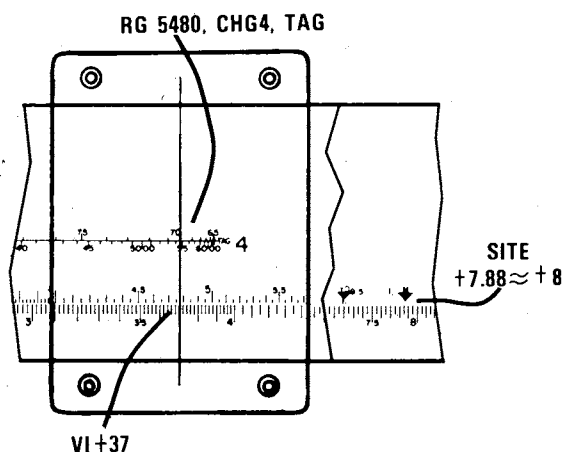


Figure 4-17. GST position to compute site of a VI of +37 at a range of 5480 meters.

- ★ *g. Range Changeover Point.* On all GSTs for all charges there is a point on all TAG and TBG scales where the scales begin to "double back;" i.e., the cursor is moved to the left rather than to the right for an increase in range for a given VI. The range at which each scale reverses direction is called the range changeover point. The location of the changeover point can be shown by plotting site as a function of site in mils and range in meters (fig 4-18).

- ★ (1) Recall that site equals the angle of site plus the complementary angle of site. In figure 4-18, at the lower ranges (5000-7000 M), the angle of site is decreasing more than comp site is increasing; thus, site decreases. At the longer ranges (8000-9000 M), the angle of site is decreasing less than the comp site is increasing; thus, site increases. The site curve shows decreasing values up to a range of approximately 7600 M and then increasing values beyond. The range at which site is an absolute minimum value is 7600 M and is thus the range changeover point.

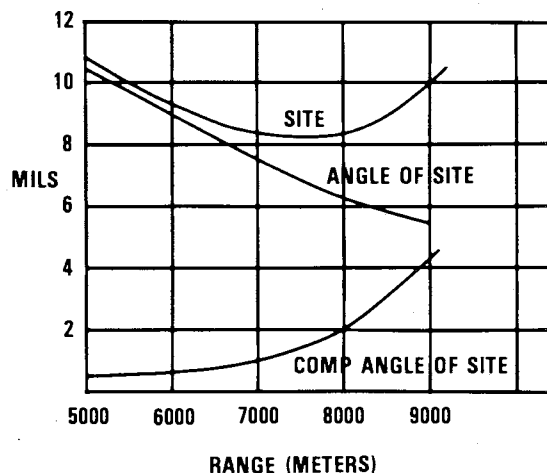


Figure 4-18. Range changeover graph.

- (2) Once the range changeover point has been passed, it is no longer valid to use the range divided by 1000 for the rough division used to determine decimal placement. The best value to use for rough division is the value read from the C scale underneath the MHL, when the MHL has been set over the range on the site-range scale.

*h. Computation of Comp Site.* Comp site can be computed to the nearest one-tenth mil by use of the GST.

- (1) Compute the angle of site to the nearest one-tenth mil.
- (2) Compute the site to the nearest one-tenth mil.
- (3) Algebraically subtract the angle of site from site.
- (4) The remainder, with its sign, is comp site to the nearest one-tenth mil.

**Example:**

The data is the same as that used in the examples in paragraph f(3), above: VI is +37 meters; range is 5480 meters; charge 4 GB, GST 155-AM-1. Angle of site is +6.9 mils. Site is +7.9 mils. Therefore, comp site is  $(+7.9) - (+6.9) = 1.0$  mil.



i. *Computation of Vertical Interval.* The vertical interval can be computed with the GST by a reverse procedure (multiplication by use of the formula  $VI = \frac{VI}{R}$ ) when the other factors are known; i.e., the angle of site and range, the vertical angle and distance, or the site, range, charge, and weapon.

(1) Move the slide until the M gagepoint is opposite the value of the angle (angle of site, vertical angle, or site) on the D scale.

(2) Move the hairline over the range (to the nearest 10 meters) on:

(a) The C scale when angle of site or vertical angle is known.

(b) The appropriate site-range scale when site is known.

(3) Read the value under the hairline on the D scale. Determine the decimal point location, express the result to the nearest 1 meter, and affix the same sign as that of the angle.

**Example:**

Site, range, and charge known: This site is +5 mils, the range is 4650 meters, charge 4 GB, GST 155-AM-1. Compute the vertical interval. Move the slide until the M gagepoint is opposite 5 on the D scale. Move the hairline over range 4650 on the charge 4 TAG site-range scale. Read 211 under the hairline on the D scale. The vertical interval is therefore +21 meters  $((+5) \times (4.65))$ .

**Example:**

Angle of site and range known: The angle of site is -11 mils, and the range is 4370 meters. Compute the vertical interval. Move the slide until the M gagepoint is opposite 11 on the D scale. Move the hairline over range 4370 on the C scale.

Read 472 under the hairline on the D scale. The vertical interval is therefore -47 meters  $((-11) \times (4.37))$ .

j. *Limitations of the GST.* The angle of site limitations for use of the GST are  $\pm 100$  mils because at this point the mil relation begins to break down and an error exceeding 1 mil is introduced. When the angle of site exceeds  $\pm 100$  mils, the following formula must be used:  $\tan \angle \text{Site} = VI/R$ .

**Example:**

Vertical interval = 600 meters



Chart Range = 5000 meters

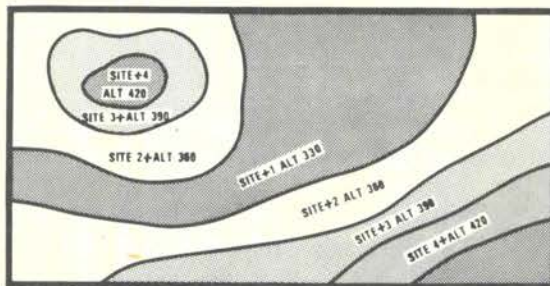
$\tan \angle \text{Si} = 600 \div 5000 = 0.12$

$\angle \text{Si} \tan 0.12$  (TM 6-230, table IV) = 122 mils

Site is then computed as described in paragraph 4-12. The maximum error in computations obtained with the GST will not exceed 1 mil if the above limitations are not exceeded.

**4-14. Average Site**

A considerable amount of time can be saved in mission processing if average site can be precomputed for the area of operations. As time permits after occupation, the VCO should develop a color-coded average site map. The average sites and altitudes would be listed within each color-coded area. Site will be computed for each 30-meter or 100-foot vertical interval. The error in site will normally be small and is an acceptable



VCO MAP COLOR-CODED AND MARKED WITH AVERAGE SITE AND CORRESPONDING ALTITUDE

tradeoff of accuracy for speed. With the GST, compute site for each 30-meter interval using the charge that will be fired and the range and altitude to the center of each 30-meter interval. When a target is plotted on the average site map, the VCO can read the site and announce the corresponding altitude to

the FADAC operator. This technique may not be practical in certain situations, for example, in mountainous terrain or in fast-moving situations. Here the VCO could use the altitude of the nearest preplotted target to compute site or ignore site if speed is essential.

## Section V. RECORD OF FIRE AND REGISTRATION/ SPECIAL CORRECTION WORKSHEET

### 4-15. Purpose

These forms are multipurpose forms organized to allow a smooth flow in the processing and determination of data. They can be used:

- To record the call for fire.
- To compute firing data for all types of missions.
- To record planned target information.

### 4-16. Use of Record of Fire

The record of fire is used for the computation of data for various missions. It serves as a permanent record of fire missions. Major sections are shown with heavy black lines. Shaded portions show items that must be sent to the cannon sections. The use of the form is shown in figures 4-19 through 4-21.

**CALL FOR FIRE BLOCK**

USED TO RECORD CALL FOR FIRE. THE RTO CIRCLES OR FILLS IN THE APPROPRIATE DATA DEPENDING ON WHETHER THE MISSION IS ADJUST FIRE, FIRE FOR EFFECT, IMMEDIATE SUPPRESSION, OR SUPPRESS.

**COMPUTATION SPACE**

THIS SPACE IS USED BY THE COMPUTER TO RECORD AND DETERMINE PERTINENT DATA.

**RECORD OF FIRE**

|                                                                                 |                              |               |                |                   |
|---------------------------------------------------------------------------------|------------------------------|---------------|----------------|-------------------|
| Observer <u>H16</u>                                                             | CALL FOR FIRE<br>AF FFE/IS/S | Tgt           | GFT R3         | △ FS              |
| Grid:                                                                           |                              |               | DFT L6         | 100/R <u>21</u>   |
| Polar: Dir                                                                      | Dis                          | U/D           | VA             | /R                |
| Shift <u>BB8472</u>                                                             | Dir <u>1020</u>              | 0r <u>210</u> | 0- <u>400</u>  | 20/R <u>4</u>     |
| Shift <u>ZSU 23-4, VT 1E</u>                                                    |                              |               | U/D <u>50</u>  | MOB Corr          |
| FIRE ORDER <u>(3), VT 1E</u>                                                    |                              |               | Si ± 10        | 10m Si            |
| INITIAL FIRE COMMANDS <input checked="" type="checkbox"/> FM MF <u>BTRY RDJ</u> |                              |               | Rg <u>4870</u> | Df Corr <u>L3</u> |
| Sp Instr                                                                        |                              |               | Sh             | Lot               |
| MTO <u>G47, (3)</u>                                                             |                              |               | Chg <u>4</u>   | Fz                |
|                                                                                 |                              |               | Ti             | Df <u>3220</u>    |
|                                                                                 |                              |               | PER            | TF                |
|                                                                                 |                              |               | (580)600       | (3) VT in Eff     |
|                                                                                 |                              |               |                | Si <u>+6</u>      |
|                                                                                 |                              |               |                | EI <u>296</u>     |
|                                                                                 |                              |               |                | QE <u>1302</u>    |

**FIRE ORDER BLOCK**

USED BY THE COMPUTER TO RECORD THE FIRE ORDER.

**INITIAL FIRE COMMANDS**

USED BY THE COMPUTER TO RECORD AND TRANSMIT FIRE COMMANDS. THOSE SHADED PORTIONS INDICATE WHAT MUST BE SENT TO THE GUNS.

**MTO BLOCK**

USED BY THE RTO TO RECORD AND SEND THE MESSAGE TO OBSERVER. AT, PER (PROBABLE ERROR IN RANGE), TOF (TIME-OF-FLIGHT). IT IS RECORDED WHEN SENT TO THE OBSERVER OR IT MAY BE RECORDED IN PARENTHESES IF DETERMINED AND NOT SENT TO THE OBSERVER.

Figure 4-19. Record of Fire—call for fire and initial computations.

*Figure 4-20. Record of Fire—subsequent corrections and fire commands.*



### RECORD OF FIRE

[illegible]

DA FORM 4504

REPLACES DA FORM 4504, 1 MAY 76 , WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPONENT AGENCY IS TRADOC

1 Oct 78

Figure 4-21. Record of Fire—planned targets.

#### 4-17. Use of the Registration/Special Correction Worksheet

The registration/special corrections worksheet is used for computation of data for

registrations, transfer of GFT settings, terrain gun position corrections, and special corrections. The major sections are shown in figures 4-22 and 4-23.

**REGISTRATION COMPUTATIONS**

**USED TO DETERMINE AND RECORD REGISTRATION CORRECTIONS WITH OR WITHOUT BASE PIECE DISPLACEMENT.**

**REGISTRATION/SPECIAL CORRECTION WORKSHEET**

| REGISTRATION COMPUTATIONS  |      |       |                               |      |       |
|----------------------------|------|-------|-------------------------------|------|-------|
| ACHIEVED RANGE             |      |       | DEFLECTION CORRECTION         |      |       |
| 1 Chart Rg                 | 5060 | (10M) | 6 Corr Df (Reg)               |      | (1pr) |
| 2 BP Displ (F-/B+)         |      | (10M) | 5 BP Displ Corr (L+ / R-)     |      | (1pr) |
| 3 Achieved Rg (1+2)        |      | (10M) | 7 Adj Df (6+5)                | 3320 | (1pr) |
| BP DISPLACEMENT CORRECTION |      |       | 8 Chart Df                    | 3304 | (1pr) |
| 4 Lateral Displ (L/R)      |      | (5M)  | 9 Total Df Corr (7-8) (+L/-R) | L16  | (1pr) |
| 3 Achieved Rg              |      | (10M) | 10 Drift Corr (~ Adj El) (L)  | L6   | (1pr) |
| 5 BP Displ Corr (4÷3)      | L/R  | (1pr) | 11 GFT Df Corr (9-10)         | L10  | (1pr) |

|       |         |        |         |        |         |                       |     |
|-------|---------|--------|---------|--------|---------|-----------------------|-----|
| GFT B | : Chg 4 | Lot YZ | Rg 5060 | El 296 | Ti 17.7 | DEFLECTION CORRECTION |     |
| GFT   | : Chg   | Lot    | Rg      | El     | Ti      | Total                 | GFT |
|       |         |        |         |        |         | L16                   | L10 |

**FADAC RESIDUALS**

**USED TO RECORD FADAC RESIDUALS**

**EXTRA COMPUTATION SPACE**

**TRANSFER OF GFT SETTING**

|      | 1             | 2                                 | 3               | 4                  | 5            | 6                           | 7                           |
|------|---------------|-----------------------------------|-----------------|--------------------|--------------|-----------------------------|-----------------------------|
| Btry | Bn BP Comp VE | MV Corr Factor D+ 28.0<br>I- 21.6 | MV Rg Corr 1x2= | Achieved Rg (5090) | Corr Rg 3+4= | El ~ 5<br>(Use EL Gageline) | Ti ~ 5<br>(Use Ti Gageline) |
|      | M/S           | M                                 | 10M             | 10M                | 10M          | pr                          | FS                          |
| C    | I 2.2         | -21.6                             | -50             | 5080               | 5030         | (316)                       | (18.5)                      |

**TRANSFER OF GFT SETTING**

**USED TO COMPUTE GFT SETTINGS FOR NON-REGISTERING BATTERIES.**

Figure 4-22. Major sections of registration/special correction worksheet.



| TERRAIN GUN POSITION / SPECIAL CORRECTIONS |                    |                                     |                        |                                                 |                   |                    |                                              |                                |                                 |                                |                                                              |                                                            |               |                                                       |         |  |  |
|--------------------------------------------|--------------------|-------------------------------------|------------------------|-------------------------------------------------|-------------------|--------------------|----------------------------------------------|--------------------------------|---------------------------------|--------------------------------|--------------------------------------------------------------|------------------------------------------------------------|---------------|-------------------------------------------------------|---------|--|--|
| LPR Sector                                 |                    |                                     |                        |                                                 |                   |                    |                                              |                                |                                 | TRANSFER LIMITS                |                                                              |                                                            |               |                                                       | Chg 4GB |  |  |
|                                            |                    |                                     |                        |                                                 |                   |                    |                                              |                                |                                 | LEFT                           |                                                              | CENTER                                                     |               | RIGHT                                                 |         |  |  |
| CEN DF+400m                                |                    |                                     |                        |                                                 | DF                | 3600               | 3200                                         | 2800                           | DF                              | CEN DF-400m                    |                                                              |                                                            |               |                                                       |         |  |  |
| CEN RG-2000M                               |                    |                                     |                        |                                                 | RG                | 3300<br>(Min)      | 5300                                         | 7300<br>(Max)                  | RG                              | CEN RG+2000M                   |                                                              |                                                            |               |                                                       |         |  |  |
| Gun                                        | Corr To Burst Line | Dir Of Corr Toward -BC - Away -BC - | Pos Lateral Corr (L/R) | 100/R GFT *<br>T 25<br>Min Rg<br>A 14<br>Max Rg | Pos Df Corr (L/R) | Btry Comp VE (I/D) | MV Unit Corr Fac (Tbl F)<br>D+29.0<br>I-22.8 | MV Rg Corr<br>$(4) \times (5)$ | Pos Rg Corr<br>(F= -)<br>(B= +) | Total Rg Corr<br>$(6) + (7) =$ | Pos El Corr<br>$(8) \div DR$<br>Per lpr D El (Tbl F)<br>(13) | Corr Rg<br>$(8) \approx 10M$<br>Plus CEN<br>Rg *<br>(5300) | Fs~<br>$(10)$ | Pos Ti Corr<br>$(11)$ Minus<br>Fs~CEN<br>Rg<br>(19.1) | Gun     |  |  |
| #                                          | #                  | T/A                                 | 5M                     | 10M                                             | 10M               | 0.1M/S             | 0.1 M                                        | 1M                             | 5M                              | 1M                             | 10M                                                          | 10M                                                        | 0.1           | 0.1                                                   | #       |  |  |
| 1                                          | 1                  | T                                   | L60                    | 25                                              | L15               | I1.3               | -22.8                                        | -30                            | -25                             | -55                            | -4                                                           | 5240                                                       | 18.9          | -0.2                                                  | 1       |  |  |
| 2                                          | 2                  | T                                   | L25                    | 25                                              | L6                | D0.6               | +29.0                                        | +17                            | -35                             | -18                            | -1                                                           | 5280                                                       | 19.0          | -0.1                                                  | 2       |  |  |
| 3                                          | 3                  | A                                   | R20                    | 14                                              | R3                | 0.0                | -                                            | -                              | -                               | -                              | 0                                                            | 5300                                                       | 19.1          | 0                                                     | 3       |  |  |
| 4                                          | 4                  | T                                   | R15                    | 25                                              | R4                | I0.7               | -22.8                                        | -16                            | +45                             | +29                            | +2                                                           | 5330                                                       | 19.3          | +0.2                                                  | 4       |  |  |
| 5                                          | 5                  | A                                   | L10                    | 14                                              | L1                | D1.2               | +29.0                                        | +35                            | +20                             | +55                            | +4                                                           | 5360                                                       | 19.4          | +0.3                                                  | 5       |  |  |
| 6                                          | 6                  | T                                   | R30                    | 25                                              | R8                | I0.3               | -22.8                                        | -7                             | -40                             | -47                            | -4                                                           | 5250                                                       | 18.9          | -0.2                                                  | 6       |  |  |

\* FOR SPECIAL CORR USE CHART RANGE TO TARGET

**TERRAIN GUN POSITION/SPECIAL CORRECTIONS**

USED TO DETERMINE DATA AS APPROPRIATE.  
SHADED BLOCKS INDICATE THE PROPER SECTOR,  
CORRECTION, AND CHARGE.

Figure 4-23. Terrain gun position/special corrections.

## ★ Section VI. SAMPLE PROBLEM

### 4-18. Data

The sample problem in this section was processed using FDC equipment for the M109A1 howitzer (GFT 155-AM-1, GST 155-AM-1). Firing data was determined with the following one-plot GFT setting:

GFT C: Chg 4, Lot XY, Rg 5240, El 334, Ti 19.3

Tot df corr: L1      GFT df corr: R6

# C1, FM 6-40

The following fire order and fire command standards are in use.

## STANDARDS:

### BATTERY FDC

| FIRE ORDER STANDARDS                                  |                  |
|-------------------------------------------------------|------------------|
| ELEMENT                                               | CURRENT STANDARD |
| UNIT TO FIRE                                          |                  |
| ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT | # 3 ①            |
| BASIS FOR CORRECTION                                  | USE GFT          |
| DISTRIBUTION                                          | PARALLEL SHEAF   |
| PROJECTILE                                            | HE               |
| AMMUNITION LOT AND CHARGE                             | XY / 4           |
| FUZE                                                  | Q                |
| NUMBER OF ROUNDS                                      | ①                |
| RANGE SPREAD, LATERAL SPREAD, ZONE, OR SWEEP          | CENTER RG & DF   |
| TIME OF OPENING FIRE                                  | WHEN READY       |

| FIRE COMMAND STANDARDS                         |                                  |
|------------------------------------------------|----------------------------------|
| ELEMENT                                        | STANDARD ELEMENTS BY CURRENT SOP |
| WARNING ORDER                                  |                                  |
| PIECES TO FOLLOW/PIECES TO FIRE/METHOD OF FIRE | # 3 ①                            |
| SPECIAL INSTRUCTIONS                           |                                  |
| PROJECTILE                                     | HE                               |
| AMMUNITION LOT                                 | XY                               |
| CHARGE                                         |                                  |
| FUZE/FUZE SETTING                              | Q                                |
| DIRECTION                                      |                                  |
| QUADRANT ELEVATION                             |                                  |
| METHOD OF FFE                                  |                                  |

#### 4-19. Adjust Fire Mission (Fuze Q in Effect)

a. The following call for fire is received in Battery C FDC and the FDO issues his fire order.

b. The FDC computes the initial fire

commands and sends the message to observer.

c. The FDC computes the subsequent fire commands and refinement data.

d. A completed record of fire is shown below:

## RECORD OF FIRE

| Observer <b>W44</b>                                              |             | CALL FOR FIRE<br><b>(AFFE)/IS/S</b> |                | Tgt _____                     | <b>TGT ALT 410 GFT R6</b><br><b>BTRY ALT 365 DFT L7</b><br><b>VI + 45</b> |           | <b>△ FS</b><br>100/R <b>20</b><br>/R _____<br>20/R <b>4</b> |                   |               |             |          |                  |            |              |            |           |
|------------------------------------------------------------------|-------------|-------------------------------------|----------------|-------------------------------|---------------------------------------------------------------------------|-----------|-------------------------------------------------------------|-------------------|---------------|-------------|----------|------------------|------------|--------------|------------|-----------|
| Grid: <b>615288</b>                                              |             |                                     |                | U/D _____ VA _____            |                                                                           |           |                                                             |                   |               |             |          |                  |            |              |            |           |
| Polar Dir _____                                                  | Dis _____   |                                     |                | L/R _____ v/- _____ U/D _____ |                                                                           |           |                                                             |                   |               |             |          |                  |            |              |            |           |
| <b>RADAR SITE</b>                                                |             |                                     |                |                               | <b>Si ÷ 10</b>                                                            |           | <b>10m Si</b>                                               |                   |               |             |          |                  |            |              |            |           |
| FIRE ORDER <b>(3)</b>                                            |             |                                     |                |                               | Df Corr <b>L1</b>                                                         |           | Si <b>+10</b>                                               |                   |               |             |          |                  |            |              |            |           |
| INITIAL FIRE COMMANDS                                            |             |                                     |                |                               | Re <b>5160</b>                                                            |           | Chf Dt <b>3315</b>                                          |                   |               |             |          |                  |            |              |            |           |
| Sp Instr _____ Sh _____ Lot _____ Chg <b>4</b> Fs _____ Ti _____ |             |                                     |                |                               | Df <b>3316</b>                                                            |           | EI <b>327</b>                                               |                   |               |             |          |                  |            |              |            |           |
| MTO <b>D46, (3)</b>                                              |             |                                     |                |                               | <b>(260)</b>                                                              |           | Ammo Exp <b>(1)</b>                                         |                   |               |             |          |                  |            |              |            |           |
| Tgt                                                              | Location    | Priority ✓                          | Firing Unit    | SUBSEQUENT FIRE COMMANDS      |                                                                           |           |                                                             |                   |               |             |          |                  |            |              |            |           |
| Chf MF Sh, Fs                                                    | Dev         | Rg                                  | NOB Corr       | Mf, Sh Chg, Fs                | FS Corr                                                                   | Ti        | Chart Df                                                    | Df Corr (L)       | Df Fired      | Chart Rg    | NOB Corr | Si 1000          | EI         | QE           | Exp        | Type      |
| <b>450</b>                                                       | <b>L120</b> | <b>+300</b>                         |                |                               |                                                                           |           | <b>3331</b>                                                 | <b>L1</b>         | <b>3332</b>   | <b>5430</b> |          | <b>+10</b>       | <b>350</b> | <b>360</b>   | <b>(2)</b> |           |
|                                                                  |             | <b>-50 FFE</b>                      | <b>BTRY(3)</b> |                               |                                                                           |           | <b>3329</b>                                                 | <b>L1</b>         | <b>3330</b>   | <b>5390</b> |          | <b>+10</b>       | <b>347</b> | <b>357</b>   | <b>20</b>  | <b>q-</b> |
|                                                                  | <b>R20</b>  | <b>+20 EM</b>                       |                |                               |                                                                           |           | <b>3326</b>                                                 | <b>L1</b>         | <b>(3327)</b> | <b>5400</b> |          | <b>+10</b>       | <b>348</b> | <b>(358)</b> |            |           |
| <b>RADAR SITE NEUTRALIZED</b>                                    |             |                                     |                |                               |                                                                           |           |                                                             |                   |               |             |          |                  |            |              |            |           |
| Btry <b>C</b>                                                    |             | DTG <b>061410JUL80</b>              |                |                               |                                                                           | Tgt _____ |                                                             | Explot Grid _____ |               |             |          | Explot Alt _____ |            |              |            |           |

**CHECK MARK  
INDICATED  
AMMO EXPENDITURE  
WAS TRANSFERRED  
TO OTHER RECORDS**

**DATA COMPUTED BASED ON  
OBSERVERS REFINEMENT DATA,BUT  
NOT SENT TO CANNON SECTIONS**

## ★ Section VII. FIRING DATA USING FADAC

#### 4-20. Firing Data

As was discussed earlier, there are three sources of firing data: TFT, GFT, and FADAC. The primary means of computing firing data is the M18 computer (FADAC). In most situations FADAC is equal to or faster than manual computations except for first round data when the GFT fan is normally faster. In all cases, FADAC is more accurate. Refer to TM 9-1220-221-10/CL (FADAC User's Manual) for required input and FADAC capabilities.

## 4-21. Manual Backup Procedures

When the FADAC becomes nonoperational, the manual backup technique is available to transfer the mission to manual data without a significant loss in speed or accuracy. This manual backup system incorporates the SITE and DF correction last computed by FADAC into the pin location on the chart. It also eliminates any discrepancies existing between FADAC and accuracy of construction of the firing chart.

*a. VCO Actions (With FADAC Derived GFT Setting on GFT Fan).*

(1) The VCO polar plots FADAC target location on the firing chart by rotating the arc of the GFT fan until the last deflection fired is measured at the deflection index.

(2) Then by moving the cursor, he places the elevation gageline over the last QE fired (ground QE).

(3) He now places a pin in the chart at the point opposite the MHL and orients a target grid over it to pick up the subsequent corrections.

(4) When additional subsequent corrections are received, he plots them from the last pin location. The deflection to fire is read from the DF index and the QE to fire (ground QE) is read under the EL gageline using the GFT fan.

*b. Computer Actions (With FADAC Derived GFT Setting on GFT).*

(1) The computer follows current mission procedures for computing initial firing data but does not perform any preparation for manual backup procedures.

(2) The computer records site, 100/R, and 20/R on the Record of Fire based on VI and initial chart range.

(3) For adjusting rounds and all fuze Q FFE rounds, the computer passes deflection

and QE to fire, as announced by the VCO, to the guns.

(4) For fuze time adjustments and FFE rounds:

(a) The computer subtracts site from ground QE announced by VCO to determine elevation.

(b) The computer places elevation determined under EL gageline of GFT and reads FS to fire under TI gageline and determines  $\Delta$  FS.

(c) The computer adds 20/R to ground QE to determine QE to fire.

(d) The deflection to fire is the deflection announced by the VCO.

(5) For fuze VT:

(a) The computer subtracts site from ground QE announced by VCO to determine elevation.

(b) The computer places elevation determined under the EL gageline of the GFT and reads FS for fuze VT corresponding to elevation.

(c) The computer adds 20/R to ground QE to determine QE to fire.

(d) The deflection to fire is the deflection announced by the VCO.

## ★ Section VIII. REFINEMENT PROCEDURES

### 4-22. Refinement Data

a. During the adjustment phase of the mission, the observer usually adjusts the trajectory to within 50 meters of the target before requesting fire for effect rounds. Upon completion of the FFE phase, the observer sends refinement data to the FDC. Elements

of refinement may include deflection, range, and/or HOB (figs 4-24 and 4-25). This refinement data places the mean point of the FFE burst over the actual target location, thereby allowing the FDC to compute accurate data to the target if future fires are required.



(1) Use the value of 100/R determined initially times the HOB refinement correction divided by 100.

(2) Apply the correction determined to the *total site* used during the time adjustment phase of the mission. Remember, if the observer sends an UP correction, the HOB refinement correction is added to the *total site* used. If the HOB correction sent is a DOWN correction, the HOB correction is subtracted.

(3) Add the HOB correction, the *total site* used during adjustment, and the new elevation determined to find the refinement quadrant elevation.

## RECORD OF FIRE

|                                                    |             |                                     |             |                               |             |                            |             |                                      |               |                      |           |                                 |            |              |          |           |  |
|----------------------------------------------------|-------------|-------------------------------------|-------------|-------------------------------|-------------|----------------------------|-------------|--------------------------------------|---------------|----------------------|-----------|---------------------------------|------------|--------------|----------|-----------|--|
| Observer <u>M46</u>                                |             | CALL FOR FIRE<br><u>AP</u> FFE/IS/S |             | Tgt                           |             | TGT ALT <u>369</u> GFT L2  |             | $\Delta$ FS <u>0.14</u>              |               |                      |           |                                 |            |              |          |           |  |
| Grid: <u>317993</u>                                |             |                                     |             |                               |             | BTRY ALT <u>344</u> DFT L7 |             | 100/R <u>34</u>                      |               |                      |           |                                 |            |              |          |           |  |
| Polar: Dir                                         |             | Dis                                 |             | U/D                           |             | VA                         |             | /R                                   |               |                      |           |                                 |            |              |          |           |  |
| Shift                                              |             | Dir                                 |             | L/R                           |             | +/-                        |             | 20/R <u>7</u>                        |               |                      |           |                                 |            |              |          |           |  |
| <u>INF Plt 110, VT 1/2</u>                         |             |                                     |             |                               |             |                            |             | HOB Corr                             |               |                      |           |                                 |            |              |          |           |  |
| FIRE ORDER <u>LOT BY, CHG 2, ②, TI 1/2</u>         |             |                                     |             |                               |             | Df Corr <u>L9</u>          |             | Si <u>+10</u>                        |               |                      |           |                                 |            |              |          |           |  |
| INITIAL FIRE COMMANDS <u>FM</u> MF <u>BTRY EDT</u> |             |                                     |             | Rg <u>2980</u>                |             | Cht Df <u>3119</u>         |             | EI <u>287</u>                        |               |                      |           |                                 |            |              |          |           |  |
| Sp Instr                                           |             | Sh                                  |             | Lot <u>BY</u> Chg <u>2</u> Fz |             | Ti                         |             | Df <u>3128</u> QE <u>297</u>         |               |                      |           |                                 |            |              |          |           |  |
| MTO <u>R38, TI 1/2, ②</u>                          |             | $\Delta$ T <u>(440)</u>             |             | PEr                           |             | TF                         |             | <u>②</u> TI in Eff Ammo Exp <u>①</u> |               |                      |           |                                 |            |              |          |           |  |
| SUBSEQUENT FIRE COMMANDS                           |             |                                     |             |                               |             |                            |             |                                      |               |                      |           |                                 |            |              |          |           |  |
| Tgt                                                | Location    | Priority                            | Firing Unit | MF, Sh, Chg, Fz               | FS Corr     | Ti                         | Chart Df    | Df Corr (L9)                         | Df Fired      | Chart Rg             | HOB Corr  | Si (HOB)                        | EI         | QE           | Exp      | Type      |  |
| <u>6240</u>                                        | <u>R100</u> | <u>+200</u>                         |             |                               |             |                            | <u>3092</u> | <u>L9</u>                            | <u>3101</u>   | <u>3170</u>          |           | <u>+10</u>                      | <u>309</u> | <u>319</u>   | <u>②</u> |           |  |
|                                                    |             | <u>-100</u>                         |             |                               |             |                            | <u>3094</u> | <u>L9</u>                            | <u>3103</u>   | <u>3080</u>          |           | <u>+10</u>                      | <u>298</u> | <u>308</u>   | <u>③</u> | <u>Q</u>  |  |
| <u>TI</u>                                          | <u>L20</u>  | <u>-50</u>                          |             | <u>FZ TI</u>                  |             | <u>14.2</u>                | <u>3099</u> | <u>L9</u>                            | <u>3108</u>   | <u>3030</u>          | <u>+7</u> | <u>+17</u>                      | <u>293</u> | <u>310</u>   | <u>①</u> |           |  |
|                                                    |             |                                     | <u>U40</u>  |                               | <u>-0.6</u> |                            |             |                                      | <u>(3108)</u> |                      |           |                                 |            | <u>310</u>   | <u>②</u> |           |  |
|                                                    |             |                                     | <u>D15</u>  | <u>BTRY ②</u>                 | <u>+0.2</u> |                            |             |                                      | <u>(3108)</u> |                      |           |                                 |            | <u>310</u>   | <u>④</u> | <u>TI</u> |  |
| <u>FFE</u>                                         |             |                                     |             |                               |             |                            |             |                                      |               |                      |           |                                 |            |              |          |           |  |
|                                                    | <u>L10</u>  | <u>+20</u>                          | <u>U5</u>   | <u>EM</u>                     |             | <u>14.3</u>                | <u>3093</u> | <u>L9</u>                            | <u>(3102)</u> | <u>3050</u>          | <u>+2</u> | <u>+19</u>                      | <u>296</u> | <u>(315)</u> |          |           |  |
| <u>EM, EST 15 CAS</u>                              |             |                                     |             |                               | <u>-0.4</u> | <u>(139)</u>               |             |                                      |               |                      |           |                                 |            |              |          |           |  |
|                                                    |             |                                     |             | NEW TI ~ NEW CHT RG           |             |                            |             |                                      |               |                      |           | NEW EI ~ NEW CHT RG             |            |              |          |           |  |
|                                                    |             |                                     |             | REFINEMENT TI                 |             |                            |             |                                      |               |                      |           | REFINEMENT CORR FOR HOB CORR U5 |            |              |          |           |  |
|                                                    |             |                                     |             |                               |             |                            |             |                                      |               | 5/R = 2              |           |                                 |            |              |          |           |  |
|                                                    |             |                                     |             |                               |             |                            |             |                                      |               | TOT FZ CORR          |           |                                 |            |              |          |           |  |
|                                                    |             |                                     |             |                               |             |                            |             |                                      |               | -0.6<br>+0.2<br>-0.4 |           |                                 |            |              |          |           |  |
| Btry <u>B</u>                                      |             | DTG <u>24 FEB 80</u>                |             | Tgt                           |             | Replot Grid                |             | Replot Alt                           |               |                      |           |                                 |            |              |          |           |  |

DA FORM 4504  
1 OCT 78

REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPONENT AGENCY IS TRADOC

Figure 4-25. Refinement procedures, fuze time.

# CHAPTER 5

## REGISTRATIONS

### Section I. REGISTRATION DESCRIPTION

#### 5-1. Reasons for Registration

a. Firing data determined from the firing tables (graphical or tabular) is based on an assumed set of standard conditions of weather, position, and materiel (fig 5-1).

b. If all conditions of weather, position, and materiel were standard, a cannon firing at a particular elevation and deflection would cause the projectile to travel the distance shown in the firing table for that elevation and charge. Since all standard conditions will never exist simultaneously, firing table data must be corrected.

c. The purpose of a registration is to

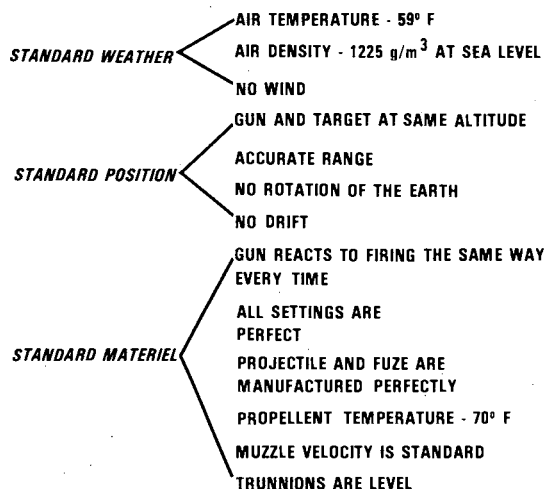


Figure 5-1. Standard conditions.

determine firing data corrections that will correct for the cumulative effects of all nonstandard conditions. With these corrections applied to firing data, a battery can rapidly and successfully engage any accurately located target within the range of their cannons and have a first round fire for effect capability.

#### WHY REGISTER?

To correct for nonstandard conditions.

To correct for errors in battery location.

To correct for errors in lay.

To correct for errors in the firing chart.

To correct for performance differences in ammunition lots.

#### 5-2. When to Register

a. A mission conducted only for the purpose of registering does not cause any damage to an enemy. It does, however, expose the firing unit to enemy target acquisition devices. These devices may detect and locate the unit and may result in the unit becoming an enemy target. In addition, missions conducted solely for the purpose of registering require additional ammunition and time. Therefore, registration missions should be held to an absolute minimum.

b. Registration is not necessary if you have confidence in (fig 5-2):

DO YOU HAVE CONFIDENCE IN:

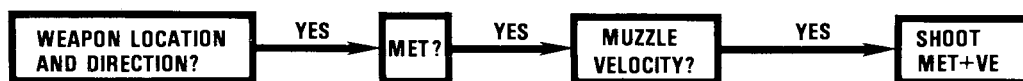


Figure 5-2. Requirements to avoid a registration.

(1) *Weapon location and directional control.* Field artillery survey provides the most accurate location and directional control for a firing battery. A firing unit can also be located with confidence using hasty survey methods outlined in FM 6-50.

(2) *Met.* If current meteorological data is not available, the following priorities for use of other met data apply (current met data is considered to be data less than 2 hours old from a station within 20 kilometers of the trajectory midpoint).

(a) Current met message (less than 2 hours old) from the nearest met station over 20 kilometers from the trajectory midpoint (upwind, if possible).

(b) Met message greater than 2 hours old from a met station within 20 kilometers of

the trajectory midpoint. A 4- or 6-hour-old message may be used except during the day/night transition (the period of time 1 hour before and 1 hour after sunrise and sunset) or following obvious weather changes. The older the message, the less likely that it will provide improvements to artillery fires. (See paragraph 6-7 for a detailed discussion of met message validity.)

(3) *Muzzle velocity.* The main causes for a change in muzzle velocity are erosion (tube wear) and changing propellant lots. Erosion is gradual and depends on the amount of firing. Wear tables in each tabular firing table may be used to help estimate when it will be necessary to perform calibration or registration.

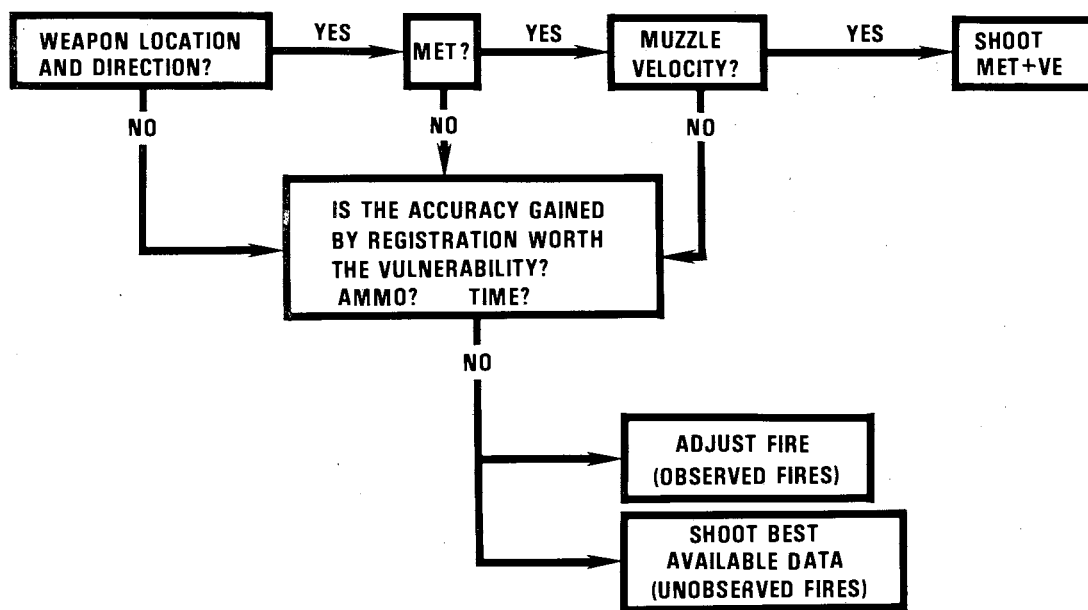
DO YOU HAVE CONFIDENCE IN:

Figure 5-3. Actions, other than registration, which may be taken.



c. The accuracy gained by registering should be weighed carefully against the vulnerability and the expenditure of ammunition and time. When registration is not possible, or when the unit will be subjected to unwarranted vulnerability by registering, use adjust fire techniques for observed fires and the best available met + VE solution for unobserved fires (fig 5-3).

### 5-3. Types of Registrations

a. *Precision Registration.* The precision registration is a technique for determining, by adjustment, the firing data that will place the mean point of impact of a group of rounds on a point of known location, called a registration point. Corrections are determined by comparing the data that was actually fired to the firing data that should have hit the target if standard conditions had existed.

b. *High Burst and Mean Point of Impact Registration.* The high burst (HB) and mean point of impact (MPI) registrations are techniques involving the firing of a group of rounds using the same firing data and then locating the MPI where the rounds actually hit. Once the MPI (or mean burst location) is determined; the data that was actually fired is compared to the data that should have hit that point if standard conditions had existed.

c. *Radar Registration.* An HB or MPI registration may be conducted using radar. Corrections are determined as described in b above.

d. *Abbreviated Registration.* This may be a precision, HB, or MPI registration. Fewer rounds are used to determine the mean point of impact; therefore, a lesser degree of accuracy can be expected.

e. *Offset Registrations.* Any type of registration may be conducted from an offset

or alternate position and may be conducted along any azimuth.

f. *Adjust Fire Mission.* If a target can be located accurately, the final data determined in an adjust fire mission (data used to fire for effect) can be compared to the firing data that should have hit the target if standard conditions had existed. Corrections are then determined as described in a above. The adjust fire method is less accurate than precision registration or HB and MPI registrations.

### 5-4. Registration Options

When the decision has been made to conduct a registration, the decision should then be made as to how the registration should be conducted (see fig 5-4). Vulnerability, time, and ammunition must be considered. Registration options are listed below.

a. *Precision and HB/MPI Registrations.* These registrations provide the highest degree of accuracy for registration corrections, but they also provide the enemy with ideal conditions for locating the firing units. An HB or MPI registration is normally quicker and takes fewer rounds than a precision registration.

b. *Abbreviated HB/MPI Registration.* An abbreviated registration is conducted exactly like an HB/MPI registration except that as few as one, two, or three rounds are actually fired. Accuracy decreases as fewer rounds are used. Table 5-1 lists the probability that the mean point of impact located by a particular number of rounds is, in fact, within one and two probable errors in range of the actual mean point of impact. As more rounds are used, the mean point of impact is more accurately located.

| NO OF ROUNDS  | 1   | 2   | 3   | 4   | 5   | 6   |
|---------------|-----|-----|-----|-----|-----|-----|
| WITHIN 1 PE   | 50% | 66% | 76% | 82% | 87% | 90% |
| WITHIN 2 PE'S | 82% | 94% | 98% | 99% | 99% | 99% |

Table 5-1. Assurance of Registration Validity.

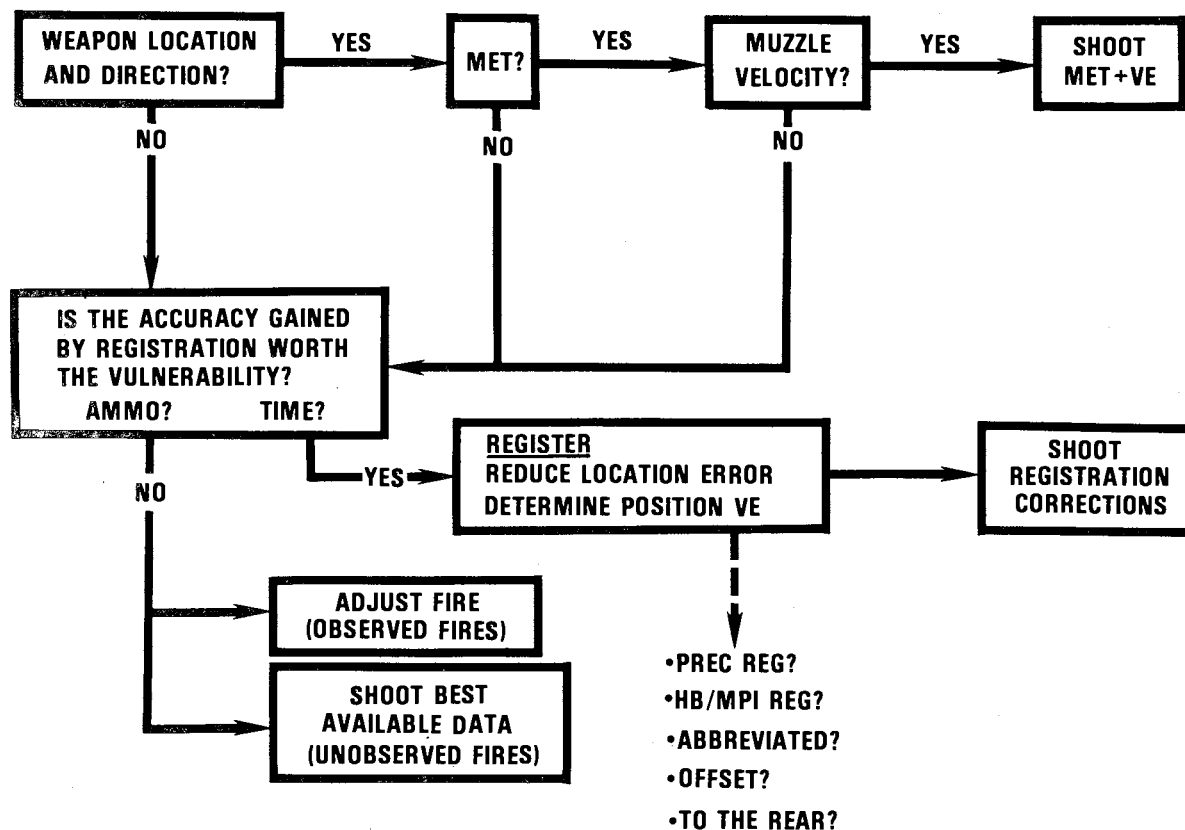
DO YOU HAVE CONFIDENCE IN:

Figure 5-4. Registration options.

*c. Abbreviated Precision Registration.* A precision registration may be ended as soon as the observer believes that his correction would put the next round fired on the registration point. Corrections may also be determined from an area fire mission if the target is *accurately* located. Again, fewer rounds are used to determine the mean point of impact, so accuracy is decreased.

*d. Offset Registration.* This is a registration conducted from a firing position away from the firing battery location. The enemy may acquire the gun's location, but the gun will not be there after the registration is completed. Simultaneous firings from other locations may disguise the registration and decrease the enemy target acquisition ability. Care must be exercised in selecting the position used for the registration since

other friendly units may be operating in the area where the registration is conducted.

*e. Registration to the Rear.* This registration is conducted in a direction away from the enemy (into friendly areas). This option will increase the range of the projectile from any enemy radars and greatly increase the enemy's target location error. Extreme care must be taken in selecting the target area since the rounds are exploding in friendly areas.

★ *f. Dual-Purpose ICM Registration.* This is a registration conducted from either the firing position or the offset position to determine corrections to be applied to the new M483A1 series of projectiles. Registrations can be conducted by using normal precision registration procedures or by using high burst, high angle registration procedures.

## Section II. PRECISION REGISTRATION

A registration will result in corrections which, when properly applied, will allow engagement of accurately located targets without adjustment—fire for effect. Precision registration is a technique that requires an observer to adjust a group of rounds fired from the same gun, so that their mean point of impact occurs at a point of known location; the point of known location is called a registration point. Registration points should be small, hard targets that are easily identified, immobile, accurately located, and not likely to be completely destroyed if hit. They should be surveyed points and their locations should be provided by a target area survey of the intended zone of operations. If a target area survey has not been conducted, registration points can be selected and located by the forward observer.

### 5-5. Initiation

- ★ a. The decision to register is based on the considerations in section I. After the decision to register has been made, the FDO announces a fire order. Like all fire orders, the fire order for a precision registration is based on the standards the FDO has designated. The FDO has established the standards

shown in figure 5-5. Charge 4 will be used to register. Normally, the charge appearing in the fire order standards will be the charge used for registration. The fire order issued by the FDO is:

**PRECISION REGISTRATION,  
USE GFT, QUICK AND TIME.**

In this example, **PRECISION REGISTRATION** tells the FDC what type mission is to be fired. **QUICK AND TIME** tells them that corrections for both fuzes, quick and time, will be determined. If there is more than one registration point available or if a second lot is to be registered, that information is also specified in the fire order. For example:

**PRECISION REGISTRATION,  
REGISTRATION POINT 3, QUICK  
AND TIME.**

or

**PRECISION REGISTRATION,  
QUICK AND TIME, TWO LOTS.**

- ★ b. Once the RATELO hears the fire order, he will send a message to observer to alert the observer.

| FIRE ORDER STANDARDS                                   |                                    |
|--------------------------------------------------------|------------------------------------|
| ELEMENT                                                | CURRENT STANDARD                   |
| UNIT TO FIRE                                           | <b>BTRY</b>                        |
| ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT  | <b># 3 ①</b>                       |
| BASIS FOR CORRECTIONS                                  | <b>FASTEST METHOD</b>              |
| DISTRIBUTION                                           | <b>PARALLEL SHEAF</b>              |
| PROJECTILE                                             | <b>HE</b>                          |
| AMMUNITION LOT AND CHARGE                              | <b>YZ / 4</b>                      |
| FUZE                                                   | <b>Q</b>                           |
| NUMBER OF ROUNDS                                       | <b>①</b>                           |
| RANGE SPREAD, LATERAL SPREAD, ZONE FIRE, OR SWEEP FIRE | <b>CENTER RANGE AND DEFLECTION</b> |
| TIME OF OPENING FIRE                                   | <b>WHEN READY</b>                  |

Figure 5-5. Fire order standards.

**C8T16, THIS IS C8T23, REGISTER  
ON REGISTRATION POINT 1.  
QUICK AND TIME, OVER.**

The registration point is always specified to the observer. The range probable error is also announced in the message to observer when it is greater than 25 meters. The fact that the range probable error is greater than 25 meters ( $PER > 25$ ) can be determined from the GFT (by inspection of the  $PER$  gagepoint) or from the TFT (table G).

c. The observer reports his direction to the FDC signifying that he is in position and ready to observe.

### 5-6. Impact Registration

a. Fire direction procedures for an impact registration are identical to those used in the conduct of any adjust fire mission. All observer corrections are either entered in FADAC and data is computed or it is plotted on the firing chart and chart data is announced. The computer sends fire commands to the registering piece. Although care should be taken during all computation steps, extraordinary measures should not be used for the conduct of a registration. For example, a plotting needle should not be used for registration and plotting pins for other missions. Remember, all nonstandard conditions are corrected for by registration, including any inaccuracies in the chart.

b. The final location of the plotting pin on the chart represents the point where the howitzer had to be aimed to hit the registration point (fig 5-6). It is not the actual location of the registration point. The difference between these locations depicts the effects that all nonstandard conditions had during firing.

c. Figure 5-7 is an example of the determination of firing data for the impact phase of precision registration. The base piece is over battery center and is the registering piece. In the example, no corrections for nonstandard conditions were available to begin the registration. Data is computed "cold stick." This has been done only for explanative purposes and is not the

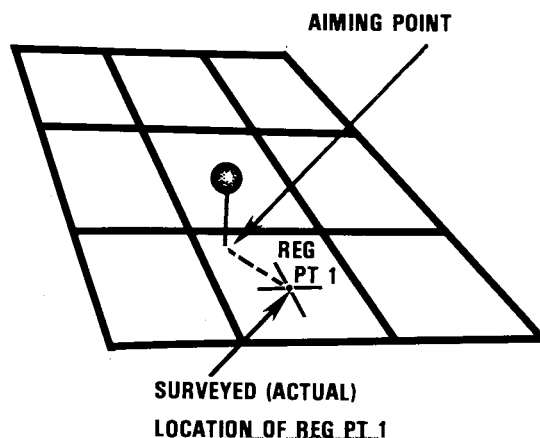


Figure 5-6. Difference between aiming point and surveyed location.

normal case. Normally, a GFT setting would be available and used for determination of firing data. The more accurate the basis for corrections used, the more likely the first rounds will be close to the registration point and could result in ammunition savings.

d. The chart data announced after the observer's refinement shows the range and deflection to the point where the guns must aim in order to hit the registration point. If firing data for fuze quick is computed based on that chart data and a fuze quick projectile is fired, it should hit the registration point. Since this is known, it is not necessary to fire the projectile and, in the example, the time phase of the registration can begin. The deflection and elevation corresponding to the chart data measured to the final pin location are called the adjusted data—the data that "did hit" the registration point. In figure 5-7 the adjusted deflection is 3190 and the adjusted elevation is 323. Both are circled.

### 5-7. Time Registration

a. When the impact phase of the registration is complete, the time phase can be started. The observer's refinement moved the mean point of impact of the rounds to the registration point and gave an adjusted deflection and elevation. The adjusted deflection and elevation are "did hit" data for the registration point and the most accurate data with which to begin the time portion.

[illegible]

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPL. AGENCY IS TRADOC

**Figure 5-7. Example of the determination of firing data.**

total site is added to the adjusted elevation to determine the quadrant to fire for the rest of the mission. The adjusted deflection is fired for the rest of the mission.

d. The adjusted time is determined after the observer's height of burst refinement is applied. The adjusted time in figure 5-8 is 19.0; it is circled. With the observer's correction applied, the adjusted time will produce an airburst 20 meters above the

b. As with other fuze time missions, a height of burst correction (20/R) is added to the ground site to determine a total site. The

### RECORD OF FIRE

|                                                                                                                                                                                                   |  |  |  |  |  |  |  |  |  |                                                               |  |  |  |  |                                                                                   |  |  |  |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|---------------------------------------------------------------|--|--|--|--|-----------------------------------------------------------------------------------|--|--|--|--|
| CALL FOR FIRE<br>Observer <u>T16</u> AF/FFE/IS/S _____ Tgt _____<br>Grid: _____<br>Polar: Dir _____ Dis _____ U/D _____ VA _____<br>Shift <u>DIR 4820</u> Dir _____ L/R _____ +/- _____ U/O _____ |  |  |  |  |  |  |  |  |  | ALT REG PT <u>376</u><br>ALT BTRY <u>352</u><br>VI <u>+24</u> |  |  |  |  | Δ FS <u>.11</u><br>100/R <u>19</u><br>/R _____<br>20/R <u>4</u><br>MOB Corr _____ |  |  |  |  |
| FIRE ORDER <u>PREC REG, USE G&amp;FT, Q&amp;TI</u>                                                                                                                                                |  |  |  |  |  |  |  |  |  | Of Corr <u>0</u>                                              |  |  |  |  | Si <u>+5</u>                                                                      |  |  |  |  |
| INITIAL FIRE COMMANDS <input checked="" type="checkbox"/> FM MF <u>BP ADJ</u> Rg <u>5420</u>                                                                                                      |  |  |  |  |  |  |  |  |  | Chf Df <u>3158</u>                                            |  |  |  |  | EI <u>327</u>                                                                     |  |  |  |  |
| Sp Instr _____ Sh _____ Lot _____ Chg <u>4</u> Fx _____ Ti _____                                                                                                                                  |  |  |  |  |  |  |  |  |  | Df <u>3158</u>                                                |  |  |  |  | QE <u>332</u>                                                                     |  |  |  |  |
| MTO <u>REG ON REG PT 1, Q&amp;TI</u> <u>(158) 1600</u> PER _____ TF _____                                                                                                                         |  |  |  |  |  |  |  |  |  | <u>Q&amp;TI</u> in Eff _____                                  |  |  |  |  | Ammo Exp <u>①</u>                                                                 |  |  |  |  |

| SUBSEQUENT FIRE COMMANDS      |            |                |             |                 |             |             |             |             |             |             |           |           |            |            |          |            |  |
|-------------------------------|------------|----------------|-------------|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------|-----------|------------|------------|----------|------------|--|
| Tgt                           | Location   | Priority       | Firing Unit | MF, Sh, Chg, Fz | FS Corr     | Ti          | Chart Df    | Df Corr (O) | Df Fired    | Chart Rg    | MOB Corr  | Si        | EI         | QE         | Exp      | Type       |  |
|                               | <u>L40</u> | <u>+200</u>    |             |                 |             |             | <u>3197</u> | <u>0</u>    | <u>3197</u> | <u>5370</u> |           | <u>+5</u> | <u>323</u> | <u>328</u> | <u>②</u> |            |  |
|                               |            | <u>-100</u>    |             |                 |             |             | <u>3178</u> | <u>0</u>    | <u>3178</u> | <u>5360</u> |           | <u>+5</u> | <u>322</u> | <u>327</u> | <u>③</u> |            |  |
|                               |            | <u>+50</u>     |             |                 |             |             | <u>3189</u> | <u>0</u>    | <u>3189</u> | <u>5360</u> |           | <u>+5</u> | <u>322</u> | <u>327</u> | <u>④</u> |            |  |
| <u>②</u>                      |            | <u>+25</u>     |             | <u>②</u>        |             |             | <u>3194</u> | <u>0</u>    | <u>3194</u> | <u>5370</u> |           | <u>+5</u> | <u>323</u> | <u>328</u> | <u>⑥</u> |            |  |
| <u>①</u>                      |            | <u>-25</u>     |             | <u>①</u>        |             |             | <u>3189</u> | <u>0</u>    | <u>3189</u> | <u>5360</u> |           | <u>+5</u> | <u>322</u> | <u>327</u> | <u>⑦</u> | <u>Q✓</u>  |  |
|                               | <u>R10</u> | <u>+10 REC</u> |             |                 |             |             | <u>3190</u> | <u>0</u>    | <u>3190</u> | <u>5370</u> |           | <u>+5</u> | <u>323</u> |            |          |            |  |
| <u>AS REG PT 1, TI RPT</u>    |            | <u>U40</u>     |             | <u>FZ TI</u>    |             | <u>19.5</u> |             |             | <u>3190</u> |             | <u>+4</u> | <u>+9</u> | <u>323</u> | <u>332</u> | <u>①</u> |            |  |
| <u>③ RPT</u>                  |            |                |             | <u>③</u>        | <u>-0.4</u> | <u>19.1</u> |             |             | <u>3190</u> |             |           |           |            | <u>332</u> | <u>②</u> |            |  |
|                               |            |                |             |                 | <u>-0.1</u> | <u>19.0</u> |             |             | <u>3190</u> |             |           |           |            | <u>332</u> | <u>⑤</u> | <u>TI✓</u> |  |
| <u>REC AS TI REG PT 1, EM</u> |            |                |             | <u>EM</u>       |             |             |             |             |             |             |           |           |            |            |          |            |  |

|               |                          |                     |                   |                  |
|---------------|--------------------------|---------------------|-------------------|------------------|
| Btry <u>B</u> | DTG <u>161425 JUN 80</u> | Tgt <u>REG PT 1</u> | Replot Grid _____ | Replot Alt _____ |
|---------------|--------------------------|---------------------|-------------------|------------------|

DA FORM 4504  
1 OCT 78

REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

☆U.S. G.P.O. 1978-280-962/8076

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPER AGENCY IS TRADOC

**Figure 5-8. Continuation of impact registration.**

registration point. The adjusted time is *not* fired.

## 5-8. Registering Piece Displacement

a. When the registering piece is the base piece, as in the previous example, the adjusted deflection, time, and elevation are determined after the observer's refinement data has been sent. They are circled on the record of fire and represent the data that should hit the registration point if fired. The range from the battery to the registration point (measured from the chart) is 5420 meters. The base piece, firing elevation 340, achieved a range of 5420.

b. When the registering piece is not over battery center, the chart range measured from battery center is *not* the range actually

achieved by the base piece (fig 5-9). With the registering piece behind the battery center, the range actually achieved, called achieved range, is greater than the chart range. To use the results of the registration on the other targets, the difference between chart range and achieved range must be taken into account.

c. When the registering piece is left or right of battery center, the correct deflection (circled on the record of fire) is *not* the adjusted deflection. If all pieces of the battery fired the correct deflection, the sheaf would not be centered over the registration point.

d. Assume that the registration used in previous paragraphs was conducted, with the registering piece not over battery center.

**The piece displacement is 40 meters behind**



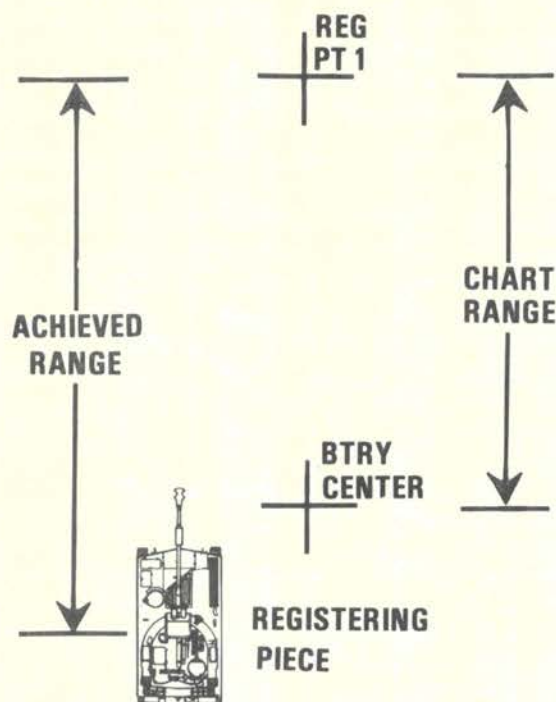


Figure 5-9. Difference between chart and achieved range.

and 25 meters left of battery center. The steps to account for piece displacement are shown on the Registration/Special Correction Worksheet. (See figure 5-10.)

(1) Determination of achieved range.

(a) Enter the chart range in block 1 of the registration computation section.

(b) Enter the piece displacement in block 2.

(c) Add or subtract (as indicated by the displacement forward or back) the piece

displacement to the initial chart range. The result is the achieved range—the range that the projectile actually traveled, which is entered in block 3.

(d) The achieved range will now be used instead of the initial chart range in determining registration corrections.

(2) Determination of adjusted deflection.

(a) The correct deflection (circled on the record of fire) is entered in block 6.

(b) The lateral displacement is entered in block 4 and the previously computed achieved range is used to convert the displacement in meters to a correction in mils.

(c) Using the GST (C and D scales, M gagepoint) divide the lateral displacement by the achieved range in thousands of meters and record the result in block 5 (25 meters  $\div$  5.46  $\approx$  5 mils).

(d) The correct deflection (block 6) is added to the piece displacement correction (block 5) and the result is the adjusted deflection (block 7).

### 5-9. Second Lot Registrations

Second lot registrations are conducted in much the same manner as are single lot registrations (fig 5-11).

a. After the first lot impact registration has been completed, a time registration is conducted, if required.

b. The first round of the second lot registration is fired with the adjusted deflection (correct deflection if base piece is

REGISTRATION/SPECIAL CORRECTION WORKSHEET

| REGISTRATION COMPUTATIONS                                  |                            |      |       |    |                            |      |       |                       |  |  |  |
|------------------------------------------------------------|----------------------------|------|-------|----|----------------------------|------|-------|-----------------------|--|--|--|
| ACHIEVED RANGE                                             |                            |      |       |    | DEFLECTION CORRECTION      |      |       |                       |  |  |  |
| 1                                                          | Chart Rg                   | 5420 | (10M) | 6  | Corr Df (Reg)              | 3170 | (1pt) |                       |  |  |  |
| 2                                                          | BP Displ (F/B)             | +40  | (10M) | 5  | BP Displ Corr (L/R)        | +5   | (1pt) |                       |  |  |  |
| 3                                                          | Achieved Rg (1+2)          | 5460 | (10M) | 7  | Adj Df (6+5)               | 3175 | (1pt) |                       |  |  |  |
| BP DISPLACEMENT CORRECTION                                 |                            |      |       |    |                            |      |       |                       |  |  |  |
| 4                                                          | Lateral Displ (L/R)        | 25   | (5M)  | 8  | Chart Df                   |      | (1pt) |                       |  |  |  |
| 9                                                          | Total Df Corr (7-8) (+L/R) |      |       | 9  | Total Df Corr (7-8) (+L/R) |      | (1pt) |                       |  |  |  |
| 3                                                          | Achieved Rg                | 5460 | (10M) | 10 | Drift Corr (~ Adj El) (L)  |      | (1pt) |                       |  |  |  |
| 5                                                          | BP Displ Corr (4÷3)        | 0.5  | (1pt) | 11 | GFT Df Corr (9-10)         |      | (1pt) |                       |  |  |  |
| GFT _____ : Chg _____ Lot _____ Rg _____ El _____ Ti _____ |                            |      |       |    |                            |      |       | DEFLECTION CORRECTION |  |  |  |
| GFT _____ : Chg _____ Lot _____ Rg _____ El _____ Ti _____ |                            |      |       |    |                            |      |       | Total GFT             |  |  |  |
| FADAC RESIDUALS Df :                                       |                            |      |       |    |                            |      |       | Rg K :                |  |  |  |

Figure 5-10. Registration computations.

not over the battery center) and the adjusted quadrant elevation (adjusted elevation + site) determined for the first lot. The adjusted deflection determined for the first lot is also used as the adjusted deflection for the second lot.

c. The FDC must announce to the observer:

**OBSERVE SECOND LOT, OVER.**

The observer must reestablish the appropriate range bracket and complete the second lot registration by using the same procedures as for the first lot.

d. The FDC determines the fuze setting for the second lot GFT setting by applying the total fuze correction from the first lot to the fuze setting corresponding to the adjusted elevation of the second lot. This allows the unit to have a fuze correction for the second lot without having to fire any more rounds at the target.

**5-10. Destruction Mission**

a. A destruction mission is simply a continuation of an impact registration designed to destroy a point target. Once the observer's refinement data for the initial impact portion of the mission has been completed, the observer will continue to request additional rounds on the target. The

observer will make additional corrections, as a minimum, after every third round and will continue until the target is destroyed or the mission is stopped for other reasons.

b. FDOs must carefully consider the size of the target versus the accuracy of their weapons at the range to the target before actually beginning the mission. Depending upon the size and type of target (bunker, tank, or APC), over 50 rounds could be expended during this type of mission, exposing the unit to detection by enemy units for long periods of time and expending large amounts of ammunition.

★ **5-11. Example of a Manual Precision Registration**

The registration in figure 5-8 was conducted using the base piece without a GFT setting. If a GFT setting had been available, the same procedures would be used except the values for elevation and the deflection correction would be determined using the elevation gageline until the impact portion was complete. The fuze setting for the initial time round would be determined corresponding to the new adjusted elevation using the MHL plus any known fuze correction.  $\Delta$ FS is determined corresponding to the first fuze setting fired.

## **Section III. HIGH BURST AND MEAN POINT OF IMPACT REGISTRATIONS**

**5-12. General**

a. When it is necessary to register, clearly defined and accurately located registration points may be limited or not available. Dense vegetation or ground fog may prevent the observers from seeing the ground. At night, the adjustment of fire on a registration point is impossible without some type of illumination. The high burst or mean point of impact registrations overcome these problems.

b. In both the HB and MPI registration, a number of rounds (usually six) are fired with the same set of firing data. These rounds are observed by two observers in surveyed

positions, usually designated O1 and O2, who have the capability to measure the direction to each bursting round. Based on the observer's average directions, the mean burst location is determined and plotted. Chart data (should hit) is then determined and compared to the data that was fired (did hit).

c. The HB registration is fired using time fuze rounds and offers an advantage over the MPI by allowing the FDC to determine a fuze correction for future missions. The high burst is also easier to observe, especially at night, and registration corrections may be determined in areas where the observers cannot see the ground.



**RECORD OF FIRE**

| Observer <u>F72</u>                                                                                                                                                                                                                                     |                         | CALL FOR FIRE<br>AP/FF/IS/S _____ Tgt _____ |               | ALT REGPT 2 390<br>ALT BTRY 355<br>VI + 35 |             | △ FS .10<br>100/R 19<br>/R _____<br>20/R 4 |          |             |          |          |          |        |       |       |     |      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------------------------|---------------|--------------------------------------------|-------------|--------------------------------------------|----------|-------------|----------|----------|----------|--------|-------|-------|-----|------|
| Grid: _____                                                                                                                                                                                                                                             |                         | Dis _____ U/D _____ VA _____                |               | Shift: _____ L/R _____ +/- _____ U/D _____ |             | NOB Corr _____                             |          |             |          |          |          |        |       |       |     |      |
| DIR 320                                                                                                                                                                                                                                                 |                         | Si ± 10                                     |               | 10m Si                                     |             |                                            |          |             |          |          |          |        |       |       |     |      |
| FIRE ORDER <u>PREC REG, USE GET REG PT 2, LOT YE FVS, Q# TI</u><br>INITIAL FIRE COMMANDS <u>BP ADJ</u> Rg <u>5420</u> Chf Df <u>3303</u> EI <u>327</u><br>Sp Instr _____ Sh _____ Lot _____ Chg <u>4</u> Fz _____ TI _____ Df <u>3303</u> QE <u>334</u> |                         |                                             |               |                                            |             |                                            |          |             |          |          |          |        |       |       |     |      |
| MTO REG ON <u>REG PT 2, Q# TI, 2 LOTS</u> <u>480</u> 500 Per < 25 TF _____ Q# TI in Eff Ammo Exp ①                                                                                                                                                      |                         |                                             |               |                                            |             |                                            |          |             |          |          |          |        |       |       |     |      |
| Tgt                                                                                                                                                                                                                                                     | Location                | Priority                                    | Firing Unit   | SUBSEQUENT FIRE COMMANDS                   |             |                                            |          |             |          |          |          |        |       |       |     |      |
| Dir, MF Sh, Fz                                                                                                                                                                                                                                          | Dev                     | Rg                                          | NOB Corr      | MF, Sh, Chg, Fz                            | FS Corr     | Ti                                         | Chart Df | Df Corr (O) | Df Fired | Chart Rg | NOB Corr | Si (H) | EI    | QE    | Exp | Type |
|                                                                                                                                                                                                                                                         | R90                     | +400                                        |               |                                            |             |                                            | 3257     | 0           | 3257     | 5730     |          | +7     | 353   | 360   | ②   |      |
|                                                                                                                                                                                                                                                         |                         | -100                                        |               |                                            |             |                                            | 3264     | 0           | 3264     | 5650     |          | +7     | 346   | 353   | ③   |      |
|                                                                                                                                                                                                                                                         |                         | +50                                         |               |                                            |             |                                            | 3260     | 0           | 3260     | 5690     |          | +7     | 349   | 356   | ④   |      |
| ②                                                                                                                                                                                                                                                       |                         | -25                                         |               | ②                                          |             |                                            | 3262     | 0           | 3262     | 5670     |          | +7     | 348   | 355   | ⑤   |      |
| ①                                                                                                                                                                                                                                                       |                         | +25                                         |               | ①                                          |             |                                            | 3260     | 0           | 3260     | 5690     |          | +7     | 349   | 356   | ⑥   | Q✓   |
|                                                                                                                                                                                                                                                         | R20                     | -10 REC                                     |               |                                            |             |                                            | 3258     | 0           | 3258     | 5680     |          |        | (348) |       |     |      |
|                                                                                                                                                                                                                                                         | AS REG PT 2, TRPT       |                                             |               | FZ TI                                      |             | 209                                        |          |             | 3258     |          | +4       | +11    | 348   | 359   | ①   |      |
| ③                                                                                                                                                                                                                                                       |                         |                                             |               | U40                                        |             | -0.4                                       | 205      |             | (3258)   |          |          |        |       | 359   | ②   |      |
|                                                                                                                                                                                                                                                         |                         |                                             |               | ③                                          |             |                                            | 205      |             | (3258)   |          |          |        |       | 359   | ③   | TI✓  |
|                                                                                                                                                                                                                                                         |                         |                                             |               | DIO                                        |             | +0.1                                       | (206)    |             |          |          |          |        |       |       |     |      |
|                                                                                                                                                                                                                                                         | REC AS TI REG PT 2, OBS |                                             |               |                                            |             |                                            | 3258     | 0           | (3258)   |          | -4       | +7     | 348   | 355   | ①   |      |
|                                                                                                                                                                                                                                                         | 2d LOT                  |                                             |               |                                            |             |                                            | 3251     | 0           | 3251     | 5740     |          | +7     | 354   | 361   | ②   |      |
|                                                                                                                                                                                                                                                         | L10                     | +100                                        |               |                                            |             |                                            | 3255     | 0           | 3255     | 5700     |          | +7     | 350   | 357   | ③   |      |
|                                                                                                                                                                                                                                                         |                         | -50                                         |               |                                            |             |                                            |          |             |          |          |          |        |       |       |     |      |
| (SEE ATTACHED RECORD OF FIRE)                                                                                                                                                                                                                           |                         |                                             |               |                                            |             |                                            |          |             |          |          |          |        |       |       |     |      |
| Tgt                                                                                                                                                                                                                                                     | Location                | Priority                                    | Firing Unit   | SUBSEQUENT FIRE COMMANDS                   |             |                                            |          |             |          |          |          |        |       |       |     |      |
| Dir, MF Sh, Fz                                                                                                                                                                                                                                          | Dev                     | Rg                                          | NOB Corr      | MF, Sh, Chg, Fz                            | FS Corr     | Ti                                         | Chart Df | Df Corr (O) | Df Fired | Chart Rg | NOB Corr | Si (H) | EI    | QE    | Exp | Type |
| ②                                                                                                                                                                                                                                                       |                         | +25                                         |               | ②                                          |             |                                            | 3253     | 0           | 3253     | 5710     |          | +7     | 351   | 358   | ⑤   |      |
| ①                                                                                                                                                                                                                                                       |                         | -25                                         |               | ①                                          |             |                                            | 3255     | 0           | 3255     | 5700     |          | +7     | 350   | 357   | ⑥   | Q✓   |
|                                                                                                                                                                                                                                                         |                         | +10 REC                                     |               |                                            |             |                                            | 210      | 3254        | 0        | (3254)   | 5710     |        |       | (351) |     |      |
|                                                                                                                                                                                                                                                         | AS REG PT 2, EM         |                                             |               | EM                                         |             | -0.3                                       | 207      |             |          |          |          |        |       |       |     |      |
| -0.4<br>+0.1<br>-0.3 TOT FZ CORR<br>1st REGISTRATION                                                                                                                                                                                                    |                         |                                             |               |                                            |             |                                            |          |             |          |          |          |        |       |       |     |      |
| Btry                                                                                                                                                                                                                                                    | B                       | DTG                                         | 141050 JUN 80 | REG PT 2                                   | Replot Grid | Replot Alt                                 |          |             |          |          |          |        |       |       |     |      |

DA FORM 4504 1 OCT 78 REPLACES DA FORM 4504, 1 MAY 78, WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40; THE PROPONENT AGENCY IS TRADOC

CUMULATIVE FUZE CORRECTION FROM 1ST LOT

ADJUSTED TIME FOR 2ND LOT

ADJUSTED DATA FROM 1ST LOT

Figure 5-11. Second lot registration.

d. The requirement for surveyed observer locations is the primary limitation of the HB and MPI registrations.

e. There are six basic steps to an HB/MPI registration.

(1) Select an orienting point.

(2) Orient the observers.

(3) Determine firing data to the orienting point.

(4) Fire the HB/MPI.

(5) Determine the mean burst location.

(6) Determine chart data and registration corrections.

### 5-13. Selecting an Orienting Point

a. The S3 or FDO selects an orienting point at which all of the rounds will be fired. This point may be located at a grid intersection for convenience. The orienting point is only a temporary point on the firing chart. Once the firing data is determined, the orienting point is no longer needed.

b. For both an HB and MPI registration, the orienting point should:

(1) Be visible to both observers.

(2) Be close to the center of the area of responsibility (unless eight-direction met is to be used to determine a valid GFT setting).

(3) Insure an apex angle of greater than 150 and preferably 300 mils. The apex angle is the angle formed by the lines from each observer to the orienting point.

(4) For an MPI, be in a relatively flat (level) area, free of obstructions.

(5) For an HB, the orienting point must be high enough to insure an airburst. Fifty meters above the ground is usually sufficient, but the selected height of burst must be at least two probable errors in height of burst above the ground.

#### *Example:*

The FDO for an M109A1 unit has selected an orienting point for an HB registration. The range to the orienting point is 5460 meters. The unit will be firing charge 4GB. Entering the TFT (table G, column 4) using charge 4 and the range expressed to the nearest 500 meters ( $5460 \approx 5500$ ), the probable error in HB is 11. Two probable errors would be 22 ( $2 \times 11 = 22$ ), that is rounded up to the nearest 10 meters ( $22 \approx 30$ ); thus, the lowest HB that should be selected is 30 meters.

c. The HB or MPI registration starts with the fire order in which the orienting point is specified (the standards used in section II are still in effect). **HIGH BURST REGISTRATION AT GRID 4861** notifies the FDC of the type of mission to be fired (an HB registration) and the location of the orienting

point (grid 4861); **HEIGHT OF BURST 50 METERS** tells the VCO the desired HB above ground level (at grid 4861) for determining site; **FUZE TIME** indicates a change from the standard fuze and **AT MY COMMAND** means that the FDO wants to control the exact time at which each round will be fired. AMC is used to insure that each observer sees each round fired.

### 5-14. Orienting the Observers

a. Once the orienting point has been selected and the fire order has been issued, the two observers must be told where to look in order to observe the rounds. The observer's locations are plotted on the firing chart and the direction and distance from each observer to the orienting point is measured. The VCO uses the distances and the vertical interval between each OP and the orienting point to determine the vertical angle for each observer. The vertical angle is determined using the C and D scales of the GST.

b. A message to observer is sent to both observers. The message to observer contains the information needed to tell the observers where to orient their instruments in order to see the bursts. It is recorded on the HB/MPI form (DA Form 4201). The message contains the following parts.

(1) *A warning order.*

#### **OBSERVE HIGH BURST REGISTRATION.**

The warning order informs the observers to prepare to observe a registration and tells them for what type of registration they are preparing.

(2) *Orienting data for observer O1.*

#### **O1 DIRECTION 510, VERTICAL ANGLE PLUS 10.**

The HCO measured the chart data from O1 to the orienting point. The direction reported to the observer is the direction determined on the firing chart. The VCO determines the altitude of the grid intersection (grid 4861), then adds the HOB to determine the altitude of the orienting point.

### ORIENTING POINT ALT = GROUND ALT + HOB

|                     |            |
|---------------------|------------|
| Ground alt          | 367        |
| + HOB               | <u>+50</u> |
| Orienting point alt | 417        |

The VCO subtracts the altitude of the observer (400) from the altitude of the orienting point to determine the vertical interval ( $417 - 400 = +17$ ). Using the C and D scales of the GST, the vertical interval (+17) and the distance measured by the HCO (1810 meters), the VCO determines O1's vertical angle (+10). The vertical angle and direction reported to O1 will allow him to orient on the orienting point.

#### Example:

$$\pi = W \div R$$

$$VA = VI \div \text{dis}$$

$$+17 \text{ (D scale)} \div 1.81 \text{ (C scale)} = +9.56 \text{ (M gagepoint, D scale)} \approx +10$$

(3) A directive to O1 to measure the vertical angle.

### MEASURE THE VERTICAL ANGLE

O1 is normally the control observation post, is more accurately located, and has the most experienced observer. O1 will measure the vertical angles that will be used to compute the altitude of the mean burst location. Only one observer's vertical angle is required.

(4) Orienting data for observer O2.

### O2 DIRECTION 6130 VERTICAL ANGLE PLUS 6.

The HCO measures the chart data from O2 to the orienting point. The VCO subtracts the altitude of the observer (405) from the altitude of the orienting point (417) to determine the vertical interval ( $417 - 405 = +12$ ). Using the C and D scales of the GST, the vertical interval (+12), and the distance measured by the HCO (2150 meters), the VCO determines O2's vertical angle (+6). The vertical angle and direction for O2 will allow him to orient on the orienting point.

(5) A directive to the observers to report when they are ready to observe.

### REPORT WHEN READY TO OBSERVE.

When the observers report they are ready to observe, the FDC can begin the registration.

c. Each observer will orient his instrument on the direction and vertical angle announced to him and report to FDC when he is ready to observe.

d. The survey section will provide the direction and distance from O1 to O2. The following was provided:

Direction O1 to O2: 1968.

Distance O1 to O2: 1422.10.

The computer records this information on the high burst form and determines the direction from O2 to O1 by adding (or subtracting) 3200 to the direction from O1 to O2 (see figure 5-12).

| HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION                                                      |                |          |             |
|-----------------------------------------------------------------------------------------------------|----------------|----------|-------------|
| For use of this form, see FM 6-40; the responsible agency is US Army Training and Doctrine Command. |                |          |             |
| COMPUTATION OF HB (MPI) LOCATION                                                                    |                |          |             |
| Message to Observer                                                                                 | OBSERVE HB REG | O1 to O2 | At O1 to O2 |
| 01 DIR 510                                                                                          | VA +10         | 1422.1   | 1968        |
| MEASURE THE VA                                                                                      |                |          | 3200        |
| 02 DIR 6130                                                                                         | VA +6          |          | 5168        |
| REPORT WHEN READY TO OBSERVE                                                                        |                |          |             |
| Date Fired                                                                                          | Chg            | O1       | FS          |

Figure 5-12. Direction from O2 to O1.

### 5-15. Determining Firing Data

a. The HCO determines the range and deflection from the battery to the orienting point and announces the data to the computer:

### BRAVO RANGE 5010. DEFLECTION 3171.

The computer records the information on the record of fire.

b. The VCO subtracts the altitude of the battery (361) from the altitude of the orienting point (417) to determine the vertical interval ( $417 - 361 = +56$ ). Using the D and SI-RG scales (chg 4) of the GST, the vertical interval (+56), and the range determined by the HCO (5010 meters), the VCO determines the site to be +13. The VCO announces the site to the computer:

**BRAVO SITE PLUS 13.**

c. The computer records the site on the record of fire and determines and announces the fire commands to the battery. No GFT setting is available.

**5-16. Firing the HB/MPI**

a. After both observers have reported they are ready to observe and the base piece announces it is ready to fire, the FDO begins firing the registration. The first round that is fired may not be observed by either of the observers; nonstandard conditions may cause the round to burst outside the field of vision of the observer's instrument. After the first round, both observers should adjust their instruments so that the actual burst location of the round is in the center of the field of vision of their instruments. There may be cases where the nonstandard conditions cause the round to land behind a hill or in a ravine, out of the sight of one or both observers. If this happens, the firing data to the orienting point is changed until both of the observers can see the bursting rounds. Remember, if the orienting point is changed to a location that is not near the original orienting point, new orienting data must be sent to the observers (a new message to observer) so they can orient on the new location. Sometimes graze bursts will occur at the start of a high burst registration. The observer's data for these rounds cannot be used to determine the mean burst location. In this case, the HOB is raised by at least two probable errors in HOB (table G of the TFT). The firing data is recomputed.

*Example:*

The observers announced that the first round fired was a graze burst. The computer uses the chart range (5010 meters expressed to 5000) and the charge (4) to enter the TFT. PEHB at 5000 = 9 meters.  $2 \text{ PEHB} = 2 \times 9 = 18 \text{ meters}$ . Express the result upward to the nearest 10 meters. 18 meters expresses to 20 meters. Using increments of 100/R, determine the site increase in mils.  $100/R = 20 \text{ mils}$ ;  $20/R = 4 \text{ mils}$ . The HOB correction (+4) is added to the old site (+13) to determine the new site  $(+4 + (+13) =$

+17). The new site is added to the elevation to determine the new quadrant elevation to fire (el 296 + (+17) = QE 313).

An alternate method would be to raise the HOB 50 meters by adding the value for 50/R to the previous site fired. Remember, the important point is to obtain an airburst.

b. Once the observers have located and oriented on the actual location of the bursting rounds, the firing data is not changed. All rounds used to locate the mean burst location must be fired with the same set of firing data. Once the observers have located the actual burst and are oriented, the method of fire may be changed to **BASE PIECE, 6 ROUNDS (or however many rounds are required) AT (so many) SECONDS**. The time interval between rounds must be long enough for the observers to identify each round and record the data to that round.

c. When the observers have reported that they have both observed the bursting round, the computer transfers the firing data to the high burst (MPI) form and writes "See attached record of high burst (MPI)" on the record of fire. All information for the rest of the registration is recorded on the high burst (MPI) form.

d. After each round fired has been observed, the observers report the direction to each round from their location and O1 reports the vertical angle from his location. The computer records the data on the high burst form as it is sent by the observers. The FDO must determine if any rounds fired were erratic and should be disregarded. There are no exact rules for determining which rounds are erratic. The following are three ways in which erratic rounds may be determined and are meant as guidelines only:

(1) Determine the mean burst location using graphic intersection (see paragraph 5-17). Using the range to the mean burst location expressed to the nearest 500 meters, determine the  $PER$  and probable error in deflection ( $PE_D$ ) and construct a box  $8 \text{ PER} \times 8 \text{ PE}_D$  centered over the mean burst location and along the gun-target line. Reject any rounds that plot outside this box (fig 5-13).



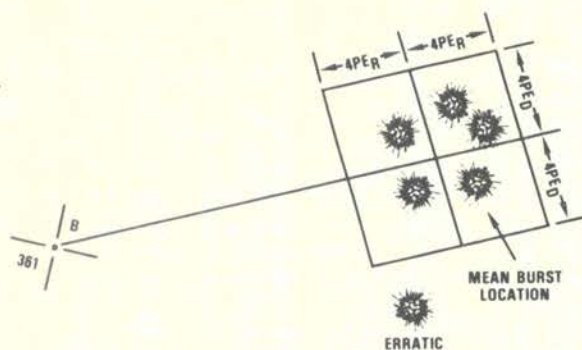


Figure 5-13. PE box for HB registration.

(2) At the range to the mean burst location expressed to the nearest 500 meters, determine the probable error in height of burst ( $PE_{HB}$ ). Using the O1's reported vertical angles, the measured distance from O1 to the mean burst location, and the ground altitude, determine the altitude of the mean burst location. Determine the altitude of each round and compare this altitude with the average altitude. Reject any round that falls outside the average altitude  $\pm 4 PE_{HB}$ .

(3) The FDO may use his judgment and experience in determining if a round should be rejected. Care must be taken to insure erratic rounds are not used or usable rounds rejected. If a round is considered erratic because of the reported direction from O1 to O2 or because of a vertical angle (VA), the data from the other observer must also be disregarded.

### 5-17. Determining the Mean Burst Location

a. The observer's measured azimuths are listed, in order for each round, on the High Burst/MPI form as they are sent to the FDC by the observers (fig 5-14). As the rounds are fired, the round number is circled to record the expenditure of rounds during the registration. As discussed in paragraph 5-16d, some rounds may be considered erratic. They are crossed out and rounds are fired to replace them.

- ★ b. Once the data from the six usable rounds is recorded, the FDC determines the mean burst location. The location is determined by using one of three methods. The methods are

|                      |      |       |       |                     |  |
|----------------------|------|-------|-------|---------------------|--|
| Data Fired           |      | Chg 4 |       | Df                  |  |
| Observer Readings    |      |       |       |                     |  |
| Rd                   | O1   |       | O2    |                     |  |
| No                   | Az   | VA    | Az    | O1 on               |  |
| ①                    | 538  | 6     | 6185  | Az O1 → HB (MPI)    |  |
| ②                    | 539  | 8     | 6188  | + 6400 if necessary |  |
| ③                    | 542  | 7     | 6186  | Total               |  |
| ④                    | 544  | 6     | 6190  | - Az O2 → HB (MPI)  |  |
| ⑤                    | 540  | 8     | 6188  | APEX 4              |  |
| ⑥                    | 543  | 7     | 6191  | Az O2 → HB (MPI)    |  |
| 7                    |      |       |       | + 6400 if necessary |  |
| 8                    |      |       |       | Total               |  |
| 9                    |      |       |       | - Az O2 → O1        |  |
| 10                   |      |       |       | 4 of O2             |  |
|                      | 3246 | 42    | 37128 | Total               |  |
|                      | 541  | 7     | 6188  | Average             |  |
| Distance O1 HB (MPI) |      |       |       |                     |  |

Figure 5-14. Observer's measured azimuth.

listed in increasing order of accuracy and order for time of computation.

(1) *Graphic intersection.* The observer's average directions are drawn on the firing chart; where the directions intersect is the mean burst location.

(2) *Polar plot.* The direction and distance from O1 to the mean burst location is determined and the mean burst location is polar plotted on the firing chart.

(3) *Grid coordinates.* The actual grid coordinates of the mean burst location are computed and plotted on the firing chart. Usually graphic intersection is performed first, followed by polar plot and grid coordinates, as time permits.

c. Graphic intersection procedures follow:

(1) The usable observer readings are totaled on the form and the average reading is obtained by dividing the total by the number of usable rounds (in this case 6). The averages are determined to the nearest mil.

(2) Using the RDP, the HCO sets off the average direction from O2 to the HB and

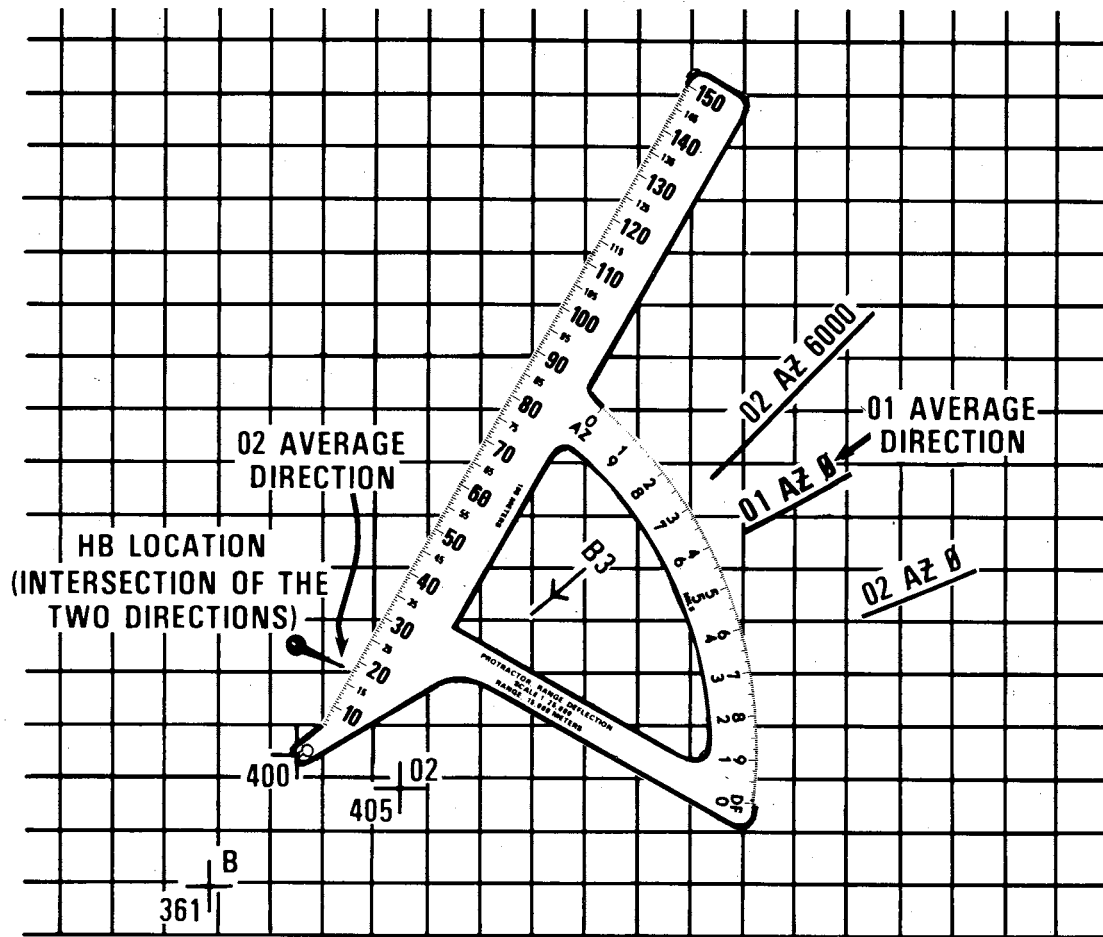


Figure 5-15. Graphic intersection method.

draws a construction line along the left edge of the RDP using a 6H pencil. He then sets off the average direction from O1 to the HB. Where the two lines intersect is the mean burst location. A pin is placed at the mean burst location and the distance O1 to HB is measured (fig 5-15).

(3) Using the distance from O1 to the mean burst location and O1's vertical angle, the altitude of the mean burst location is determined.

(a) The HCO uses the RDP and measures the distance from O1 to the mean burst location. He announces the result to the VCO:

**O1 DISTANCE 1740.**

(b) The VCO uses O1's average vertical angle (+7), the distance (1740 meters), and the GST to determine the vertical interval between O1 and the mean burst location ( $+7 \times 1740$  meters, C and D scale of GST = vertical interval (+12 meters)).

(c) The VCO adds the vertical interval (+12) to the altitude of O1 ( $400 + (+12) = 412$ ). The altitude of the mean burst location is 412.

d. Polar plot procedures follow:

(1) Determine the average observer readings as explained in c above.

(2) Determine the interior angles of a triangle formed by the two observers and the mean burst location using the next section of the form (fig 5-16).

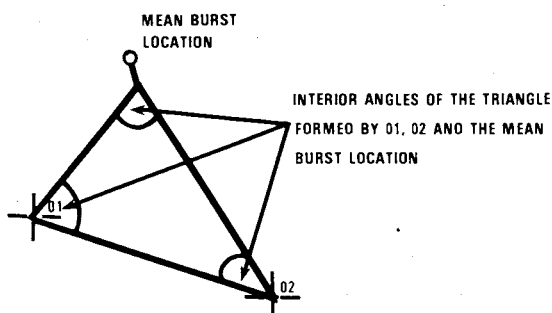


Figure 5-16. Determination of interior angles formed by observers.

If O1 is on the left of O2, cross out the section marked O1 on the right. If O1 is on the right of O2, cross out the section marked O1 on left.

**Note.** O1 is left or right of O2 with respect to how they are looking at the orienting point, *not* with respect to the gun-target line.

(3) Completing the appropriate side of the form, determine the angle at O2 ( $\angle$  at O2) (fig 5-17).

| CT) REGISTRATION<br>US Army Training and Doctrine Command. |                 |                    |     |
|------------------------------------------------------------|-----------------|--------------------|-----|
| 1) LOCATION                                                |                 |                    |     |
| Dis<br>O1 → O2<br>1422.1                                   | Az O1 → O2<br>⊕ | 1968               |     |
|                                                            |                 | 3200               |     |
|                                                            | Az O2 → O1      | 5168               |     |
| DI 3171                                                    | FS 17.9         | QE                 | 309 |
| Interior Angles                                            |                 |                    |     |
| O1 on Left                                                 |                 | O1 on Right        |     |
| Az O1 → HB (MPI)                                           | 541             | Az O2 → HB (MPI)   |     |
| +6400 if necessary                                         | 6400            | +6400 if necessary |     |
| Total                                                      | 6941            | Total              |     |
| -Az O2 → HB (MPI)                                          | 6188            | -Az O1 → HB (MPI)  |     |
| APEX $\angle$                                              | 753             | APEX $\angle$      |     |
| Az O2 → HB (MPI)                                           | 6188            | Az O2 → O1         |     |
| +6400 if necessary                                         | —               | +6400 if necessary |     |
| Total                                                      | 6188            | Total              |     |
| -Az O2 → O1                                                | 5168            | -Az O2 → HB (MPI)  |     |
| $\angle$ at O2                                             | 1020            | $\angle$ at O2     |     |
| Total                                                      |                 |                    |     |
| Average                                                    |                 |                    |     |

Figure 5-17. Determination of the angle at O2.

| Reg                         | O1 | O2 | O1 on Left              |
|-----------------------------|----|----|-------------------------|
| No                          | Az | Az |                         |
| 1                           |    |    | Az O1 → HB (MPI) 541    |
| 2                           |    |    | +6400 if necessary 6400 |
| 3                           |    |    | Total 6941              |
| 4                           |    |    | -Az O2 → HB (MPI) 6188  |
| 5                           |    |    | APEX $\angle$ 753       |
| 6                           |    |    | Az O2 → HB (MPI) 6188   |
| 7                           |    |    | +6400 if necessary —    |
| 8                           |    |    | Total 6188              |
| 9                           |    |    | -Az O2 → O1 5168        |
| 10                          |    |    | $\angle$ at O2 1020     |
| 3246                        |    |    | 37128                   |
| 541                         |    |    | 6188                    |
| Distance O1 HB (MPI)        |    |    |                         |
| Log base O1 → O2            |    |    | 3 152 930               |
| + Log sin $\angle$ at O2    |    |    | 9 925 424               |
| Sum                         |    |    | 3 078 354               |
| - Log sin Apex Angle        |    |    | 9 828 491               |
| DIFF - Log dist O1 HB (MPI) |    |    | 3 249 863               |
| Dist O1 → HB (MPI)          |    |    | 1 778                   |

| CT) REGISTRATION<br>US Army Training and Doctrine Command. |                 |                    |     |
|------------------------------------------------------------|-----------------|--------------------|-----|
| 1) LOCATION                                                |                 |                    |     |
| Dis<br>O1 → O2<br>1422.1                                   | Az O1 → O2<br>⊕ | 1968               |     |
|                                                            |                 | 3200               |     |
|                                                            | Az O2 → O1      | 5168               |     |
| DI 3171                                                    | FS 17.9         | QE                 | 309 |
| Interior Angles                                            |                 |                    |     |
| O1 on Left                                                 |                 | O1 on Right        |     |
| Az O1 → HB (MPI)                                           | 541             | Az O2 → HB (MPI)   |     |
| +6400 if necessary                                         | 6400            | +6400 if necessary |     |
| Total                                                      | 6941            | Total              |     |
| -Az O2 → HB (MPI)                                          | 6188            | -Az O1 → HB (MPI)  |     |
| APEX $\angle$                                              | 753             | APEX $\angle$      |     |
| Az O2 → HB (MPI)                                           | 6188            | Az O2 → O1         |     |
| +6400 if necessary                                         | —               | +6400 if necessary |     |
| Total                                                      | 6188            | Total              |     |
| -Az O2 → O1                                                | 5168            | -Az O2 → HB (MPI)  |     |
| $\angle$ at O2                                             | 1020            | $\angle$ at O2     |     |
| Total                                                      |                 |                    |     |
| Average                                                    |                 |                    |     |

Figure 5-18. Determine O1 distance to mean burst location.

- ★ (4) After the angle at O2 is determined, compute the distance from O1 to the mean burst location using logarithms found in TM 6-230, *Logarithmic and Mathematical Tables*. Use the section of the form labeled DISTANCE O1 HB (MPI) to determine the distance O1 to the mean burst location (fig 5-18). The military slide rule or a calculator may also be used to compute the distance from O1 to the mean burst location. The formula in figure 5-19 must be used.

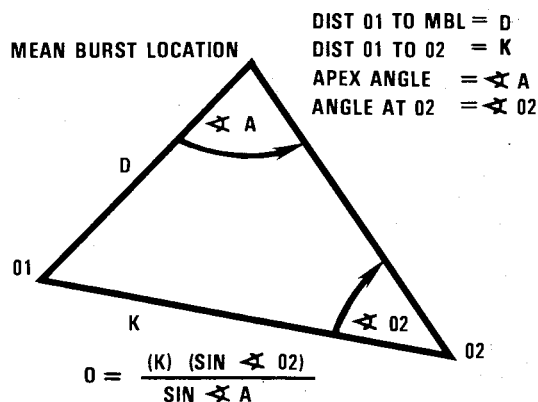


Figure 5-19. To compute the distance from O1 to mean burst location.

(5) The distance from O1 to the mean burst location is expressed to the nearest 10 meters (1778 meters  $\approx$  1780 meters).

(6) The HCO places the vertex of the RDP on O1 and moves the RDP to the average direction determined for O1 to the mean burst location (541 mils). A pin is placed at the

distance determined for O1 to the mean burst location (1780 meters). This is the mean burst location (fig 5-20).

(7) The VCO uses the average vertical angle determined for O1 (+7), the distance from O1 to the mean burst location (1780 meters), and the GST to determine the vertical interval between O1 and the mean burst location ( $+7 \times 1780$  meters, C and D scales of GST = VI (+12)). The vertical interval (+12) is added to the altitude of O1 (400) to determine the altitude of the mean burst location ( $400 + (+12) = 412$ ).

e. Grid coordinate procedures follow:

(1) Compute the average directions, interior angles, and distance from O1 to the mean burst location as in paragraphs c and d above.

(2) Determine the bearing angle from O1 to the mean burst location. Using the diagram, with the top of the form representing north or 0 mils, draw a line approximately along the average azimuth from O1 to the mean burst location. This line will be drawn in one of the four quadrants of the diagram. In each quadrant are the instructions for determining the bearing angle in that quadrant (fig 5-21).

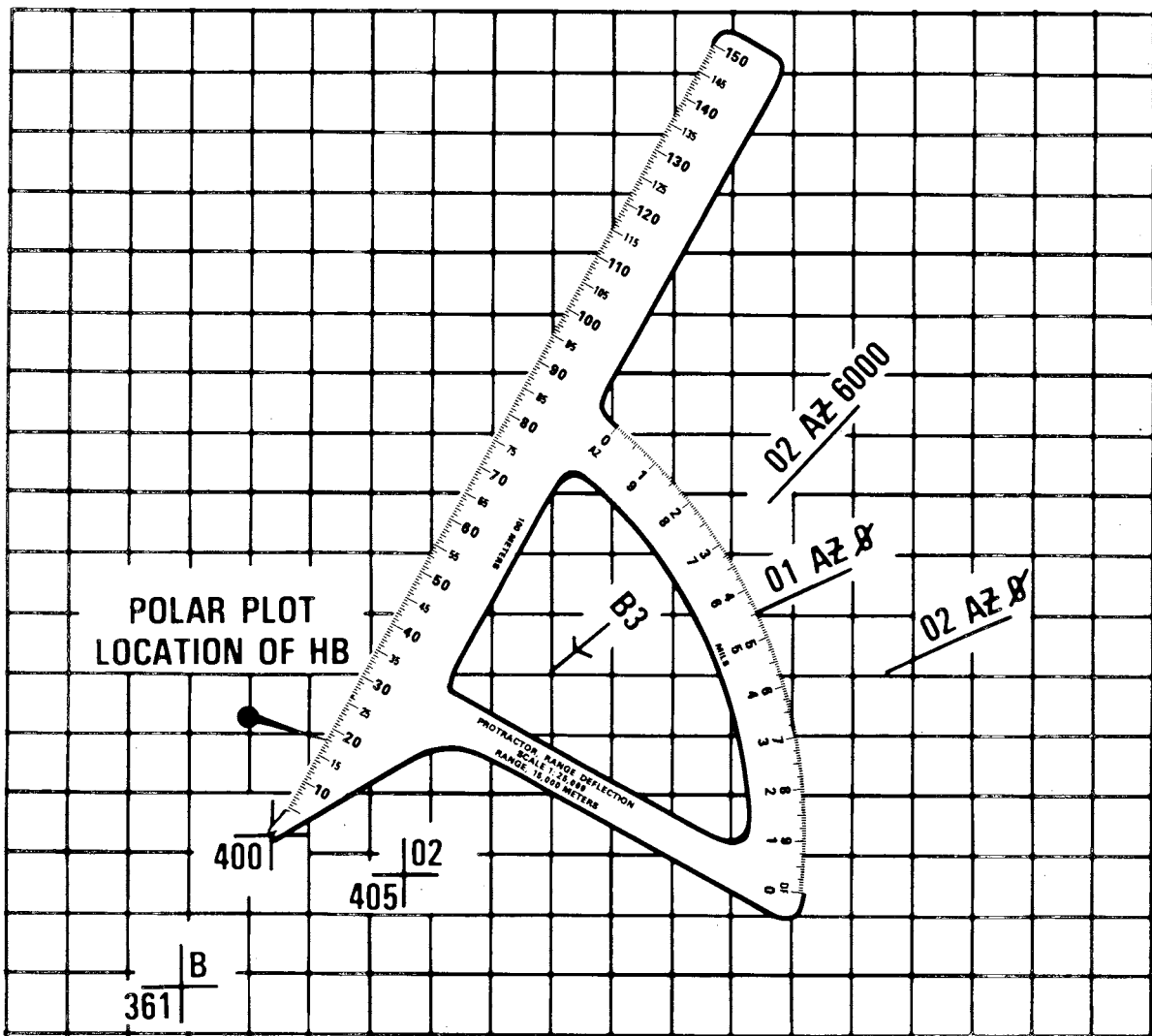
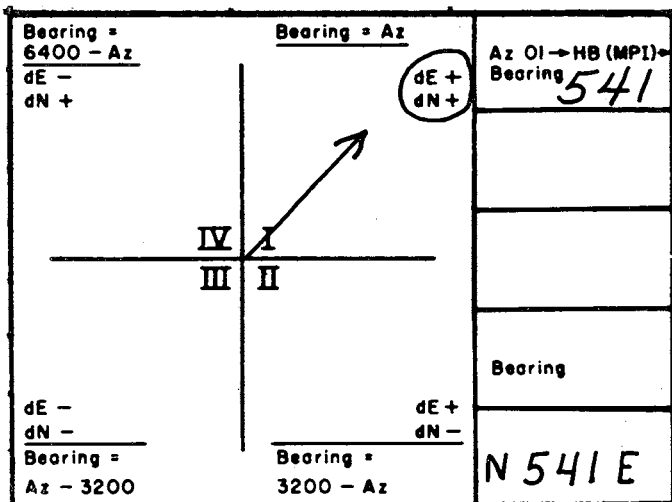


Figure 5-20. Polar plot the mean burst location.





LINE REPRESENTING THE  
 AZIMUTH FROM 01 (THE  
 CENTER OF DIAGRAM) TO  
 THE MEAN BURST LOCATION .

Figure 5-21. Determining the bearing angle.

|                                    |               |                       |       |                                        |                       |                               |                                                 |
|------------------------------------|---------------|-----------------------|-------|----------------------------------------|-----------------------|-------------------------------|-------------------------------------------------|
| 9                                  |               |                       |       | -Az O2 $\rightarrow$ O1                |                       | -Az O2 $\rightarrow$ HB (MPI) |                                                 |
| 10                                 |               |                       |       | $\Delta$ at O2                         | 1020                  | $\Delta$ at O2                |                                                 |
|                                    | 3246          | $\frac{+}{42}$        | 37128 | Total                                  | Bearing = $6400 - Az$ | Bearing = Az                  | Az OI $\rightarrow$ HB (MPI) Bearing <b>541</b> |
|                                    | 541           | $\frac{+}{7}$         | 6188  | Average                                | $dE -$<br>$dN +$      | $dE +$<br>$dN -$              |                                                 |
| Distance OI HB (MPI)               |               |                       |       |                                        |                       |                               |                                                 |
| Log base OI $\rightarrow$ O2       |               | 3 152 930             |       |                                        |                       |                               |                                                 |
| + Log sin $\Delta$ at O2           |               | 9 925 424             |       |                                        |                       |                               |                                                 |
| Sum                                |               | 3 078 354             |       |                                        |                       |                               |                                                 |
| - Log sin Apex Angle               |               | 9 828 491             |       |                                        |                       |                               |                                                 |
| diff = Log dist OI HB (MPI)        |               | 3 249 863             |       |                                        | $dE -$<br>$dN -$      | $dE +$<br>$dN -$              |                                                 |
| Dist OI $\rightarrow$ HB (MPI)     |               | 1 778                 |       |                                        | Bearing = $3200 - Az$ |                               | <b>N 541 E</b>                                  |
| Log of dE, dN, and dH              |               |                       |       |                                        |                       |                               |                                                 |
| Log dist OI $\rightarrow$ HB (MPI) |               | 3 249 863             |       | Log dist OI $\rightarrow$ HB (MPI)     |                       | 3 249 863                     |                                                 |
| Log sin Bearing                    |               | 9 704 583             |       | Log cos Bearing                        |                       | 9 935 627                     |                                                 |
| Sum = Log dE                       |               | 2 954 446             |       | Sum = Log dN                           |                       | 3 185 490                     |                                                 |
| Log Tan Vert $\Delta$              |               | 7 837 105             |       | Sum = Log dH                           |                       | 1 086 968                     |                                                 |
| Coordinates of OI                  |               | E 47 323 0            |       | N 59 162 0                             |                       | H 400 0                       |                                                 |
| $\oplus$ -dE                       |               | 900 4                 |       | $\oplus$ -dN                           |                       | 1 532 8                       |                                                 |
| $\oplus$ -dH                       |               | 12 2                  |       |                                        |                       |                               |                                                 |
| Location of HB (MPI)               |               | E 48 223 4            |       | N 60 694 8                             |                       | H 412 2                       |                                                 |
| COMPUTATION OF GFT SETTING         |               |                       |       |                                        |                       |                               |                                                 |
| Alt HB (MPI)                       |               | QE fired              |       | Chart data to HB (MPI) location        |                       |                               | Df corr                                         |
| -Alt Btry                          |               | - Site VI/HB (MPI) Rg |       | Deflection _____ m Range _____ M       |                       |                               |                                                 |
| VI                                 | $\frac{+}{-}$ | Adj Elev              |       | GFT " _____ " Charge _____ Lot _____   |                       |                               |                                                 |
|                                    |               |                       |       | Range _____ Elevation _____ Time _____ |                       |                               |                                                 |

Figure 5-22. Computation of mean burst location.

(3) Using the log of dE (difference in easting), dN (difference in northing), and dH (difference in height) portion of the form and the surveyed coordinates of O1, determine the coordinates of the mean burst location. The distances determined for dE and dN are either subtracted from or added to the surveyed coordinates of O1 depending on the quadrant entered by the bearing angle. Each quadrant lists whether dE and dN are plus (+) or minus (-). If the average vertical interval is plus, the value of dH is added to O1's altitude. If the average vertical angle is minus, the value of dH is subtracted from O1's altitude.

★ A military slide rule or a calculator may be used to compute the mean burst location and altitude.

(4) The mean burst location (grid 48223 60695, altitude 412) is plotted on the chart in the same manner as any surveyed location.

### 5-18. Determining Chart Data

a. After the location of the mean burst location has been plotted on the chart, the HCO measures the range and deflection to the plotted position from the battery that fired the mission. The range and deflection measured are the chart range and chart deflection and are recorded as shown in figure 5-23.

b. The VCO determines site by determining the vertical interval between the mean burst location and the battery and, using the GST, divides this value by the chart range just determined. Site is always determined using the chart range (fig 5-23).

| COMPUTATION OF GFT SETTING      |                          |      |                     |
|---------------------------------|--------------------------|------|---------------------|
| Chart data to HB (MPI) location | Deflection <u>3183</u> m |      | Range <u>4890</u> m |
| GFT                             | Charge                   | Lot  |                     |
| Range                           | Elevation                | Time |                     |

Figure 5-23. Measured range and deflection.

### ★ 5-19. Determining Adjusted Data

a. *Adjusted Elevation.* The quadrant elevation used to fire the six usable rounds in the registration is the adjusted quadrant elevation. The site (para 5-18b) is subtracted

from the adjusted quadrant elevation and the result is the adjusted elevation (fig 5-24).

| COMPUTATION OF GFT SETTING      |                          |          |                     |
|---------------------------------|--------------------------|----------|---------------------|
| All HB (MPI)                    | 412                      | QE fired | 309                 |
| Chart data to HB (MPI) location | Deflection <u>3183</u> m |          | Range <u>4890</u> m |
| Alt Btry                        | 361                      | Site     | +12                 |
| VI                              | 251                      | Adj Elev | 297                 |

Figure 5-24. Determination of the adjusted elevation.

#### b. Adjusted Deflection.

(1) If the base piece or the firing weapon is over battery center, the deflection used to fire the six usable rounds in the registration is the adjusted deflection.

(2) If the base piece or firing weapon is not over battery center, the deflection used to fire the six usable rounds is the correct deflection. The adjusted deflection is determined in the same manner as the adjusted deflection for a precision registration when the base piece is not over battery center (see para 5-8d(2)).

#### c. Adjusted Time.

(1) If the vertical interval between the battery and the mean burst location is less than or equal to 100 meters, the fuze setting used to fire the six usable rounds is the adjusted time.

(2) If the vertical interval is greater than 100 meters, the adjusted time must be modified to correct for an inaccuracy introduced by the large complementary angle of site. The 100-meter VI is only a rule of thumb; CAS may affect adjusted time at VIs less than 100 meters. The FDO should check the effects of CAS any time he feels it will affect adjusted time.

(a) Any fuze setting is determined as a function of the elevation and complementary angle of site to a target. When the vertical interval is less than or equal to 100 meters, the CAS is so small that it has little effect on the quadrant and fuze setting fired and is disregarded. The CAS is small when compared to the elevation and will not affect the fuze setting.

(b) If the vertical interval is greater than 100 meters, the value of the complementary angle of site becomes

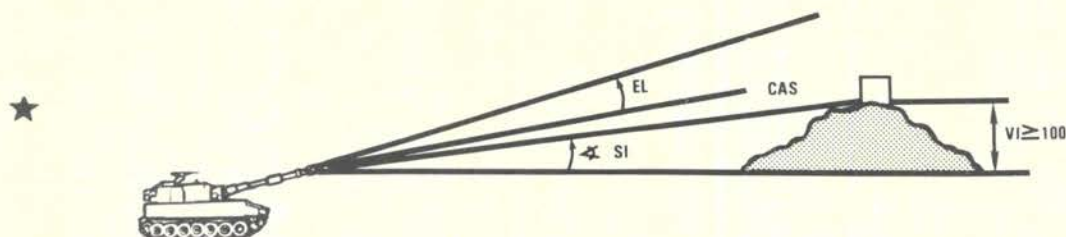


Figure 5-25. Adjusted time with VI greater than 100.

increasingly large and begins to affect the fuze setting. In this case, the CAS must be added to the elevation to determine the proper fuze setting.

(c) As the CAS increases, the fuze setting also must be increased to reach the desired bursting location. If the effect of CAS is not included in the fuze setting, the projectile will burst before reaching the desired location.

(d) The adjusted time when the vertical interval is greater than 100 meters is determined as follows:

1. Determine the angle of site and site to the mean burst location (use the GST).

2. Determine the complementary angle of site by subtracting the angle of site from site:  $Si - \angle Si = CAS$ .

3. Add the complementary angle of site to the adjusted elevation and determine the fuze setting corresponding to this elevation plus comp site:

★  $FS \sim el + CAS$

4. Subtract this fuze setting corresponding to  $el + CAS$  from the fuze setting fired in the registration. The result is the total fuze correction:  $(FS \text{ fired}) - (FS \sim el + CAS) = \text{Tot fz corr}$ .

5. Add the total fuze correction to the fuze setting corresponding to the adjusted elevation. The result is the proper adjusted time:  $(FS \sim adj el) + (\text{tot fz corr}) = \text{adj ti}$ .

★ (e) Example of the determination of adj time ( $VI > 100$ ):

Given: Registration charge: Charge 4  
Adjusted elevation: 302

Vertical interval: +150  
Chart range: 5000 meters  
Fuze setting fired during registration: 18.1

1. Determine site and the angle of site. Site. VI + 150, charge 4 at 5000 meters GST. SI-RG scale = +34. Angle of site. VI + 150, C and D scale of GST at range 5000 = +31.

2. Determine the complementary angle of site. Site - angle of site = complementary angle of site. +34 - (+31) = +3.

3. Determine the elevation + CAS. Adjusted elevation plus complementary angle of site =  $el + CAS$ .  $302 + (+3) = 305$ .

4. Determine the fuze setting corresponding to elevation plus comp site.

← GFT Place MHL of GFT on 305.  
MHL Read FS of 18.4 under MHL

305  
18.4

5. Determine the total fuze correction. Fuze setting fired in registration - fuze setting corresponding to the elevation + CAS = total fuze correction.  $18.1 - 18.4 = -0.3$ .

6. Determine adjusted time. Fuze setting corresponding to adjusted elevation + total fuze correction = adj time.

302  
18.2  
+(-0.3)  
17.9 ← adj time

(3) If the vertical interval to the orienting point is greater than 100 meters, the fuze setting to fire the HB should be the fuze setting corresponding to the elevation plus complementary angle of site. This procedure

will place the burst as close as possible to the altitude on which the observers are oriented.

#### 5-20. Example of a High Burst Registration

a. A 155-mm howitzer battalion M109A1 has just made a night occupation of a forward position. Survey has been completed but the unit has not received any met data for several hours. The S3 decides to fire a high burst registration (chg 4) in order to provide accurate fire during the night. The orienting point is selected at grid intersection 6242 with a desired HB of 50 meters. The same standards are in effect. The VCO determines that the altitude of grid intersection 6242 is 437 meters. The base piece is over battery center.

b. Survey has provided the following information:

|                      |             |
|----------------------|-------------|
| Grid B Battery       | 57085 38148 |
| Altitude B Battery   | 391 meters  |
| Grid - O1            | 61599 39123 |
| Altitude - O1        | 436 meters  |
| Grid - O2            | 60396 39620 |
| Altitude - O2        | 431 meters  |
| Distance - O1 to O2  | 1302 meters |
| Direction - O1 to O2 | 5199 mils   |

c. The HCO measures the direction and distance from O1 to O2 to the orienting point.

O1 to grid 6242: direction 141 mils distance 2900 meters

O2 to grid 6242: direction 604 mils distance 2870 meters

d. The VCO computes the vertical angles from O1 to O2 to the orienting point.

(1) Desired altitude of high burst is 487 meters ( $437 + 50$  meters HOB).

(2) O1 vertical interval = +51 (487 meters - 436 meters) vertical angle = +18 (VI +51/2900 meters distance, GST).

★ (3) O2 vertical angle = +20 (VA +56/2870 meters distance, GST).

e. The FDC determines and sends the message to observers using the directions and vertical angles determined.

**OBSERVE HIGH BURST REGISTRATION,**

**O1 DIRECTION 141, VERTICAL ANGLE PLUS 18,**

**MEASURE THE VERTICAL ANGLE.**

**O2 DIRECTION 604, VERTICAL ANGLE PLUS 20,**

**REPORT WHEN READY TO OBSERVE.**

f. The HCO measures and announces the following chart data to the computer:

**BRAVO RANGE 6240, DEFLECTION 3177.**

g. The VCO computes and announces:

**SITE BRAVO, PLUS 20.**

(Alt OP 487 - 391 = +96; +96/rg 6240, GST, chg 4: +20)

h. The computer determines and sends the following fire commands:

**BASE PIECE ADJUST, AT MY COMMAND, CHARGE 4, FUZE TIME, 23.6, DEFLECTION 3177, QUADRANT 418.**

i. The base piece and both observers report **READY** and the firing is begun. FDC personnel record the direction and vertical angle announced by the observers. When six usable rounds have been observed, the mission is ended. The coordinates of the mean burst location are computed as shown in figure 5-26.

j. The HCO plots the mean burst location on the firing chart (grid 61903 41930, altitude 491) and measures the following chart data:

|            |      |
|------------|------|
| Range      | 6130 |
| Deflection | 3178 |

k. The VCO using the altitude of the mean burst location and the chart range, determines site. Site = +22 (VI = +500 - 391 = +109. +109/rg 6130, GST, chg 4 = +22).

l. The computer determines the adjusted data.

(1) Since there is no base piece

| HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION                                                    |          |                           |          |                                   |                            |            |                                |                                  |  |  |  |
|---------------------------------------------------------------------------------------------------|----------|---------------------------|----------|-----------------------------------|----------------------------|------------|--------------------------------|----------------------------------|--|--|--|
| For use of this form, see FM 6-40; the proponent agency is US Army Training and Doctrine Command. |          |                           |          |                                   |                            |            |                                |                                  |  |  |  |
| COMPUTATION OF HB (MPI) LOCATION                                                                  |          |                           |          |                                   |                            |            |                                |                                  |  |  |  |
| Message to Observers <b>OBSERVE HB REG</b>                                                        |          |                           |          |                                   | Dis<br>O1 → O2<br><br>1302 | Az O1 → O2 |                                | 5199                             |  |  |  |
| O1 DIR 141 VA +18<br>MEASURE THE VA                                                               |          |                           |          |                                   |                            | ⊕          |                                | 3200                             |  |  |  |
| O2 DIR 604 VA +20<br>REPORT WHEN READY TO<br>OBSERVE                                              |          |                           |          |                                   |                            | Az O2 → O1 |                                | 1999                             |  |  |  |
| Data Fired                                                                                        |          | Chg 4                     |          | Dt 3177                           |                            | FS 23.6    |                                | QE 418                           |  |  |  |
| Observer Readings                                                                                 |          |                           |          |                                   | Interior Angles            |            |                                |                                  |  |  |  |
| Rd                                                                                                | O1<br>Az | VA                        | O2<br>Az | O1 on Left                        |                            |            | O1 on Right                    |                                  |  |  |  |
| ①                                                                                                 | 111      | +23                       | 593      | Az O1 → HB (MPI)                  |                            |            | Az O2 → HB (MPI)               |                                  |  |  |  |
| ②                                                                                                 | 107      | +21                       | 588      | +6400 if necessary                |                            |            | +6400 if necessary             |                                  |  |  |  |
| ③                                                                                                 | 109      | +25                       | 591      | Total                             |                            |            | Total                          |                                  |  |  |  |
| ④                                                                                                 | 108      | +24                       | 585      | -Az O2 → HB (MPI)                 |                            |            | -Az O1 → HB (MPI)              |                                  |  |  |  |
| ⑤                                                                                                 | 112      | +22                       | 587      | APEX 4                            |                            |            | APEX 4                         |                                  |  |  |  |
| ⑥                                                                                                 | 113      | +23                       | 590      | Az O2 → HB (MPI)                  |                            |            | Az O2 → O1                     |                                  |  |  |  |
| 7                                                                                                 |          |                           |          | +6400 if necessary                |                            |            | +6400 if necessary             |                                  |  |  |  |
| 8                                                                                                 |          |                           |          | Total                             |                            |            | Total                          |                                  |  |  |  |
| 9                                                                                                 |          |                           |          | -Az O2 → O1                       |                            |            | -Az O2 → HB (MPI)              |                                  |  |  |  |
| 10                                                                                                |          |                           |          | 4 at O2                           |                            |            | 4 at O2                        |                                  |  |  |  |
| 660                                                                                               |          | +138                      | 3534     | Total                             |                            |            | Bearing = 6400 - Az            |                                  |  |  |  |
| 110                                                                                               |          | +23                       | 589      | Average                           |                            |            | dE -<br>dN +                   |                                  |  |  |  |
| Distance O1 HB (MPI)                                                                              |          |                           |          |                                   |                            |            | Az O1 → HB (MPI) - Bearing 110 |                                  |  |  |  |
| Log base O1 → O2                                                                                  |          |                           |          |                                   |                            |            | Bearing = Az                   |                                  |  |  |  |
| + Log sin 4 at O2                                                                                 |          |                           |          |                                   |                            |            | dE +<br>dN +                   |                                  |  |  |  |
| Sum                                                                                               |          |                           |          |                                   |                            |            | Bearing                        |                                  |  |  |  |
| - Log sin Apex Angle                                                                              |          |                           |          |                                   |                            |            | N 110 E                        |                                  |  |  |  |
| diff = Log dist O1 HB (MPI)                                                                       |          |                           |          |                                   |                            |            |                                |                                  |  |  |  |
| Dist O1 → HB (MPI)                                                                                |          |                           |          | Log of dE, dN, and dH             |                            |            |                                |                                  |  |  |  |
| Log dist O1 → HB (MPI) 3 450 802                                                                  |          |                           |          | Log dist O1 → HB (MPI) 3 450 802  |                            |            |                                | Log dist O1 → HB (MPI) 3 450 802 |  |  |  |
| Log sin Bearing 9 032 548                                                                         |          |                           |          | Log cos Bearing 9 997 462         |                            |            |                                | Log Tan Vert 4 8 353 802         |  |  |  |
| Sum = Log dE 2 483 350                                                                            |          |                           |          | Sum = Log dN 3 448 264            |                            |            |                                | Sum = Log dH 1 804 604           |  |  |  |
| Coordinates of O1                                                                                 |          |                           |          | E 61 599 0 N 39 123 0 H 436 0     |                            |            |                                |                                  |  |  |  |
|                                                                                                   |          |                           |          | ⊕ dE 304 3 ⊕ dN 2 807 2 ⊕ dH 63 7 |                            |            |                                |                                  |  |  |  |
| Location of HB (MPI)                                                                              |          |                           |          | E 61 903 3 N 41 930 2 H 499 7     |                            |            |                                |                                  |  |  |  |
| COMPUTATION OF GFT SETTING                                                                        |          |                           |          |                                   |                            |            |                                |                                  |  |  |  |
| Alt HB (MPI) 500                                                                                  |          | QE fired 418              |          | Chart data to HB (MPI) location   |                            |            |                                | Dt corr                          |  |  |  |
| - Alt Btry 391                                                                                    |          | - Site VI/HB (MPI) Rg +22 |          | Deflection 3178 m Range 6130 m    |                            |            |                                |                                  |  |  |  |
| VI ⊕ 109                                                                                          |          | Adj Elev 396              |          | GFT * Charge Lot                  |                            |            |                                |                                  |  |  |  |
|                                                                                                   |          |                           |          | Range Elevation Time              |                            |            |                                |                                  |  |  |  |

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Figure 5-26. Sample HB registration.

displacement, the deflection fired is the adjusted deflection.

Adjusted Deflection = 3177

(2) The adjusted elevation is determined by subtracting the site to the mean burst location from the quadrant elevation fired during the high burst.

Adjusted Elevation = QE 418 - (site + 22) = 396.

(3) The adjusted time must be computed since the vertical interval is greater than 100 meters.

(a) Determine complementary angle of site.

Site -  $\angle$  Si = CAS.

+22 - (+18) = +4

(b) Determine the elevation + CAS and the corresponding fuze setting.

Adjusted elevation + CAS = elevation + CAS.

396 + (+4) = 400

FS ~ 400 = 23.7

(c) Determine the total fuze correction.  
FS fired - FS corresponding to elevation + CAS = tot fz corr

23.6 - 23.7 = -0.1

(d) Determine adj time.

(FS ~ adj el) + tot fz corr = adj ti

FS ~ 396 = 23.5

23.5 + (-0.1) = 23.4 (adj ti = 23.4)

## Section IV. RADAR OBSERVED HIGH BURST AND MEAN POINT OF IMPACT REGISTRATIONS

### 5-21. Employment

a. Employment and position requirements for the radar set depend on the tactical mission assigned to the radar section and on certain technical and tactical factors that influence the operation of this equipment. The complete suitability of a radar site can be determined only by the accomplishment of the assigned mission from that site.

b. Ideally, the radar should be located adjacent to one of the firing batteries to simplify communications, to facilitate survey and logistics, and to take advantage of an existing defensive perimeter. However, because the radar is extremely vulnerable to enemy electronic countermeasures, it may be necessary to select the radar position at some distance from the firing units in order to minimize the chances of receiving hostile fire on both the radar and the firing unit positions. The range capabilities of the radar should be considered in the selection of the radar position so that as many units as possible may take advantage of the

registration capability of the radar without degradation of the primary countermortar or counterbattery mission of the radar.

c. The radar should be placed in defilade to protect personnel and equipment from hostile fire and to reduce the effects of electronic countermeasures.

### 5-22. Advantages

The advantages of a radar registration are listed below.

a. Requires only one OP, which is the radar.

b. Requires less survey, fewer communications facilities, and less coordination.

c. Can be conducted quickly.

d. Can be conducted during periods of poor visibility with MPI techniques.

e. Can be conducted for high angle fire with MPI techniques.

f. Can be conducted from a defilade position.

### 5-23. Considerations

a. A high burst registration can only be conducted when the selected point is optically visible from the radar.

b. Ranges measured from the radar to the high burst (MPI) are slant ranges. For plotting and computational purposes, the horizontal range error introduced is insignificant and the radar slant range is considered to be horizontal range.

★ c. A radar registration (AN/MPQ-4, AN/TPQ-36/37) is similar to the regular HB/MPI registration except as follows:

(1) The AN/TPQ-36/37 radar is oriented by providing the radar, through secure means, with:

- (a) Grid of the orienting point.
- (b) Altitude of the orienting point.
- (c) Angle T.
- (d) Maximum ordinate.
- (e) Quadrant elevation.
- (f) Time of flight.

(g) Target number, if interfaced with TACFIRE.

(h) Gun to end point range.

(2) The AN/MPQ-4 radar is oriented by either of two methods:

(a) The preferred method is to send the radar the grid of the orienting point.

(b) An alternate method is to send the direction and distance to the orienting point; however, this method is discouraged because of the lack of security.

(3) In an HB registration, because the radar is in defilade, the AN/MPQ-4 radar determines a height of burst (high enough to be visible) and reports the altitude to the FDC.

(4) After registration, the radar reports the mean burst location to the FDC. The AN/TPQ-36/37 radar determines if the orienting data provides sufficient height of

burst. During the registration, the radar reports the burst location for each round to the FDC.

d. The six steps used in a regular HB/MPI registration are also used in a radar registration.

### STEPS IN A RADAR HB/MPI REGISTRATION

Select an orienting point.

Orient the observers (radar).

Determine firing data to the orienting point.

Fire the HB/MPI.

Determine mean burst location.

Determine chart data and registration corrections.

### 5-24. Selecting an Orienting Point

a. Some coordination and mutual understanding must exist between the fire direction center and the radar personnel in the choice of an orienting point. The FDC requires that the quadrant elevation and the vertical interval to the orienting point computed from the battery center not exceed the limitations stated on the back of the appropriate graphical site table. Exceeding these limitations introduces errors that are not acceptable. Use the next higher charge if quadrant is exceeded.

★ b. For a high burst registration, the selected orienting point must be optically visible from the radar. For the radar to optically observe elevation deviations above and below the selected point, the pointing elevation of the radar must be at least 10 mils (AN/MPQ-4) or 15 mils (AN/TPQ-36/37) above the elevation to the radar screening crest. The AN/MPQ-4 operator measures the elevation to the screening crest from the radar along the azimuth to the selected burst point by sighting through the optical telescope. No alinement is required for the AN/TPQ-36/37 radar, as the onboard



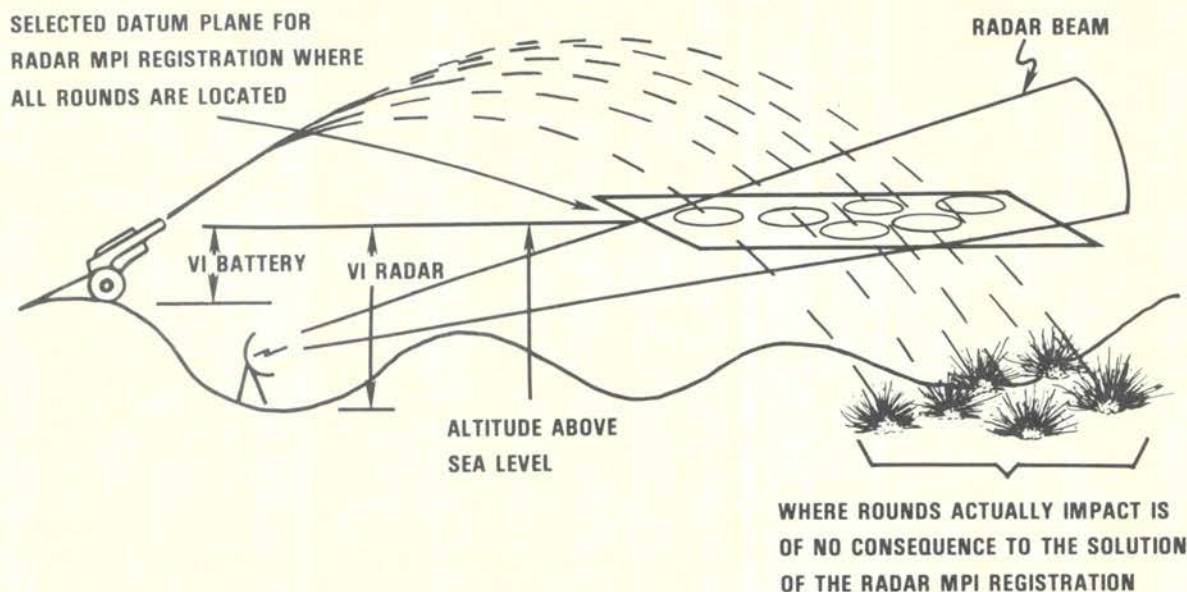


Figure 5-27. The selected datum plane.

computer will indicate if the radar is unable to intersect the trajectory in case of crest mask screening. The pointing elevation of radar, if possible, should not exceed 50 mils for the AN/MPQ-4 radar, 330 mils for the AN/TPQ-36 radar, and 210 mils for the AN/TPQ-37 radar. The need for coordination between the FDC and the radar personnel in selection of the orienting point now becomes apparent.

c. For a radar registration, only an electrical line of sight is necessary. The pointing elevation to the orienting point is determined in the same manner as for the high burst registration, insuring electrical beam clearance. A characteristic of the radar MPI registration is that the rounds usually cannot be observed at impact, because the radar usually is sited behind a mask. Therefore, the radar must observe the rounds at some place in space where they all pass through the radar beam or where the radar can intersect the projectile and continue its tracking of the projectile as in the case of the AN/TPQ-36/37 radar systems. This place in space is called the selected datum plane—the theoretical horizontal plane of the radar beam from which radar personnel in the AN/MPQ-4 or AN/TPQ-36/37 radar system

can compute the selected datum plane did hit, or chart location, of the six usable rounds (fig 5-27).

d. Once the orienting point is selected, the FDO issues his fire order. (The standards in section II apply.)

#### ★ 5-25. Orienting the Radar

The registration is initiated by a message to observer. The purpose of this message is to inform the radar of the mission and to provide that information required to prepare the radar set for that mission. The message to observer for each radar system is slightly different, but it generally consists of five elements. These elements are discussed below in the sequence in which they are transmitted with the differences between radar systems identified.

a. *Warning Order.* The warning order must always be included. It consists of the order **OBSERVE HIGH BURST (MPI) REGISTRATION FOR \_\_\_\_\_**. This informs the radar of the type of registration to be fired and the unit firing the registration so preparations can begin immediately. The firing unit is identified by



either the call sign or the code name of the unit.

*b. Orienting Data.* The radar is oriented by transmitting a properly authenticated warning order consisting of the grid of the orienting point or by polar plot as in the AN/MPQ-4 radar system. When using polar plot, the following procedures are used:

(1) The AN/MPQ-4 radar is oriented by sending a direction and a distance to the orienting point.

(2) The radar may report back either an altitude or a vertical angle. If radar reports a vertical angle, the FDC determines the altitude. In the AN/TPQ-36 or -37 radar system, the orienting data consists of the following:

(a) The grid of the orienting point, to include the altitude.

(b) The grid of the firing unit (incoded or secure voice).

(c) Maximum ordinate of the trajectory.

(d) The quadrant elevation used to fire the registration.

(e) The time of flight and a target number, if the radar is interfaced with TACFIRE.

*c. Altitude Report.* The altitude report consists of the command **REPORT ALTITUDE**. The radar section determines the vertical angle based on the radar elevation to a point 10 mils above the crest and in the direction determined to the orienting point grid. Using the vertical angle and the distance from the radar to the orienting point, the radar section determines the altitude of the orienting point. For a high burst registration, the orienting point must be 2 PEHB above the ground. If the altitude sent by radar is not 2 PEHB above the ground, the FDC raises the orienting point to the altitude required by applying the value of 2 PEHB to the altitude used and announces the new altitude to the radar.

*d. Report Order.* The report order must always be included and consists of the order **REPORT WHEN READY TO OBSERVE**.

*e. Sample Orienting Information.*

(1) AN/MPQ-4 radar.

OBSERVE RADAR MPI REGISTRATION FOR T6Y47 GRID 6336. AT MY COMMAND, REPORT WHEN READY TO OBSERVE. OVER.

(2) AN/TPQ-36 or -37 radar.

OBSERVE RADAR HB REGISTRATION FOR T6Y47 GRID 6336. ALTITUDE 378. RANGE 18350. ANGLE T 1430. MAX ORD 300. QUADRANT 372. TIME OF FLIGHT 27. REPORT WHEN READY TO OBSERVE. OVER.

## 5-26. Determining Firing Data

The determination of firing data is the same as a regular HB or MPI registration. In an HB registration with radar, the vertical interval is often greater than 100 meters. When this is the case, the fuze setting to fire should be determined corresponding to elevation plus comp site. Chart data is determined as usual; site is determined after the radar reports an altitude.

## ★ 5-27. Firing the HB/MPI

*a.* The AN/TPQ-36/37 radar uses the orienting data to check the trajectory and determine whether it fits the radar's capabilities. The radar determines whether the data is acceptable, marginal, or unacceptable before firing. The radar section reports when they are ready to observe. For the AN/TPQ-36/37, the radar reports **READY TO OBSERVE, AT MY COMMAND (REQUEST SHOT AND SPLASH)**. For the AN/MPQ-4 radar, the report includes the desired altitude of the orienting point. Usually, it contains a request

for splash and firing at their command (allowing them to turn on the radar set only when required, lowering the chances of detection).

**ALTITUDE 450, AT MY COMMAND, REQUEST SPLASH, READY TO OBSERVE, OVER.**

b. When the radar reports **READY TO OBSERVE** and the base piece reports **READY**, firing is begun. If the first round is not visible, the AN/TPQ-36/37 radar indicates what the problem is. The radar operator informs the battery as to the exact problem and requests modification to the initial firing data. All changes to the firing data must be forwarded to the AN/TPQ-36/37 radar operator. If the first round is not visible in the telescope reticle and on the B-scope of the AN/MPQ-4 radar, the antenna is reoriented to the center of the burst and the round is not used. If the first round bursts more than 5 mils below the center of the reticle, the altitude must be increased and the round is not used. As each round is fired, the radar operator reports **OBSERVED** or **UNOBSERVED**. If the report **OBSERVED** is followed by **REQUEST SITE INCREASE** early in the registration, the burst is occurring too low. The quadrant elevation must be increased by the number of mils necessary to raise the burst approximately 2 PEHB using the procedures outlined in paragraph 5-16a.

c. In determining which rounds are usable, the FDO has a number of options:

(1) For the AN/MPQ-4 radar, he may allow the radar to determine which rounds are usable. The radar chief would use the guidelines in paragraph 5-16d for a regular high burst registration in determining usable rounds.

(2) He may issue guidance to the radar chief as to how to determine usable rounds. This guidance would be based on the FDO's experience.

(3) For the AN/TPQ-36/37 radar, the grid and altitude of each round are reported,

allowing the FDO to determine the usable rounds. The AN/MPQ-4 radar also has this capability.

#### ★ 5-28. Determining the Mean Burst Location

The AN/TPQ-36/37 radar reports the burst location and altitude of each round fired. In an MPI registration, the radar computes and reports the mean burst location and altitude of the selected datum plane. The average of the reported grid and altitude is used in computing chart data and registration corrections.

a. As the rounds are fired, the AN/MPQ-4 radar may report the direction, distance, and vertical angle to each round or may report the average direction, distance, and vertical angle once all rounds have been fired.

b. Using the average direction, distance, and vertical angle, the FDC plots the mean burst location and determines the altitude.

c. Because the polar plot method may reveal the radar's location to the enemy, it should not be used unless communications are secure. Furthermore, this technique is more complicated than the grid coordinate method.

#### 5-29. Determining Chart Data and Registration Corrections

Once the mean burst location and altitude are reported, the procedures for computing chart data and registration corrections are the same as a regular HB/MPI registration.

#### 5-30. Example of a Radar MPI

a. An artillery battalion (155-mm how, M109A1) has just occupied a new position area during an intense fog. Survey has been completed but, because of the fog, the established OPs have a very limited visibility. An AN/MPQ-4A radar section is available for registration. Since the battalion must fire a preparation the following morning and accurate fire for effect fires must be delivered, the FDO decides to conduct a radar observed MPI registration at grid

intersection 6336 (CHG 4 GB). Checking the established fire order standards, he announces his fire order. (Standards are the same as in section II.)

#### **RADAR MPI REGISTRATION AT GRID 6336, AT MY COMMAND.**

The altitude of the battery is 348 and the altitude of the radar is 358.

b. The HCO measures and announces the following data from B battery to grid intersection 6336:

|            |      |
|------------|------|
| Range      | 5180 |
| Deflection | 3047 |

c. The FDC sends the following message to observer:

**OBSERVE MPI REGISTRATION FOR B8H66, GRID 6336, REPORT ALTITUDE, REPORT WHEN READY TO OBSERVE.**

d. The radar section personnel turn the radar set toward the orienting point and measure the vertical angle required to see over the screening crest. Using this vertical angle and the distance to the orienting point, they determine the minimum altitude for the point and send the following report to the FDC:

**ALTITUDE 422, AT MY COMMAND, REQUEST SPLASH, READY TO OBSERVE, OVER.**

e. Using the altitude reported by the radar section, the VCO determines the site to the orienting point.

|          |     |
|----------|-----|
| Alt Tgt  | 422 |
| Alt Btry | 348 |
| VI       | +74 |

f. The computer determines the firing data based on the chart data and site and announces the fire commands to the battery.

g. The base piece reports **READY** and the radar section is notified that the battery is ready to begin firing. Firing is initiated and continued until six usable rounds are fired. After the rounds are completed, the radar section personnel determine the mean burst location and altitude and report that to the FDC:

**MPI REGISTRATION OBSERVED;  
MEAN BURST LOCATION 62935  
35425, ALTITUDE 434.**

h. The HCO plots the location on the firing chart and measures the following chart data.

|            |      |
|------------|------|
| Range      | 4830 |
| Deflection | 3053 |

i. The VCO uses the altitude and chart range to the mean burst location and determines the site.

$\text{Alt } 434 - \text{alt btry } 348 = \text{VI } +86$

$\text{VI } +86/\text{rg } 4830, \text{chg } 4 \text{ GB, GST} = \text{site } +20$

j. Using the new chart data, the computer determines the adjusted data.

(1) The base piece was over battery center so the deflection fired is the adjusted deflection, and the chart range to the mean burst location is the achieved range.

$\text{Adjusted deflection} = 3047$

(2) The adjusted elevation is determined by subtracting the site to the mean burst location from the quadrant elevation fired during the registration:

$\text{QE } 324 - (+20) = \text{adj el } 304$

## **Section V. SPECIAL REGISTRATIONS**

### **5-31. Abbreviated Registrations**

a. *Definition.* An abbreviated registration is a registration that is halted before all of the rounds normally required have been fired. Usually it is conducted whenever the risk of

detection by enemy target acquisition devices is high or ammunition is critical. The abbreviated registration may either be a precision or a high burst (MPI) registration. Fire direction procedures are the same as for a full registration.

*b. Abbreviated Precision Registration.*

(1) The abbreviated precision registration is conducted exactly as the normal precision registration is except that the forward observer terminates the registration as soon as he believes that his next correction would place the round on the target. The FDC plots this last correction and determines chart data to the pin location. The computer determines a final set of firing data to this location. This data is not fired but is used as the adjusted data. If an adjusted time is required, the final set of firing data (plus 20/R) is fired as in a normal precision registration. The time portion of the registration may be abbreviated.

(2) An abbreviated precision registration may also be conducted while firing at a target of opportunity. If the target (preferably a point target) can be *accurately* located, the battery assumes that the target location is a registration point. The fire for effect data is used as the adjusted deflection, time, and quadrant as in a precision registration. The chart data is the data to the actual, accurately located position of the target. If the forward observer (FO) sends any refinement data, the corrections are plotted and a new, modified, set of fire for effect data is determined and used as the adjusted data. The final data must be modified by any base piece displacement when determining the corrections.

*c. Abbreviated High Burst/MPI.* An abbreviated high burst or MPI registration requires firing fewer usable rounds. Table 5-1 gives the probability of the resulting mean burst location being within one or two probable errors of the actual MPI.

### 5-32. Offset Registrations

*a. Definition and Conduct.* An offset registration is a registration (precision or high burst/MPI, abbreviated or completed) conducted by one gun from a position away from the rest of the battery. Any howitzer of the battery can conduct the registration. The registration is conducted following the normal procedures for the type registration being fired. The position from which the

registration will be conducted must be coordinated to insure there are no other friendly units in the area as the registration may draw enemy counterbattery fire. The offset position should be on common survey with the battery to insure that any corrections for survey errors in the offset position are valid in the battery position. In addition, common directional control should be established.

*b. Adjusted Data.*

(1) Adjusted data and resulting corrections determined from the offset position are valid for that position within the normal range and deflection transfer limits. If the base piece is the registering weapon, the same corrections are applied to the battery position.

(2) If a weapon other than the base piece is used to conduct the registration, the resulting corrections and GFT setting for the offset position must be transferred to the actual battery position including the modification for the difference in muzzle velocity between the weapon and the base piece. The corrections are computed using the Registration/Special Correction Worksheet, using the procedures as explained in paragraph 7-10. The transfer limits must still be compared to the unit's zone of fire and additional GFT settings computed as required. Caution must be exercised to insure data is transferred from the registering weapon to the base piece correctly. The registering weapon's comparative VE is zero and base piece is compared to that.

*Example:*

No. 1 conducted a registration. No. 1 has an MVV of -1.2. Base piece has an MVV of -0.2. The battery comparative VE of No. 1 normally would be -1.0 when compared to base piece. However, when No. 1 conducts a registration, base piece is compared to it. The battery comparative VE for base piece is +1.0 and this value is used to compute the GFT setting.

(3) The registration corrections are based on the azimuth and range from the offset position to the registration point. It is

assumed that if a registration were conducted from the battery area using the same range and azimuth (as from the offset position), the adjusted data and resulting corrections would be the same as those obtained in the offset position (fig 5-28).

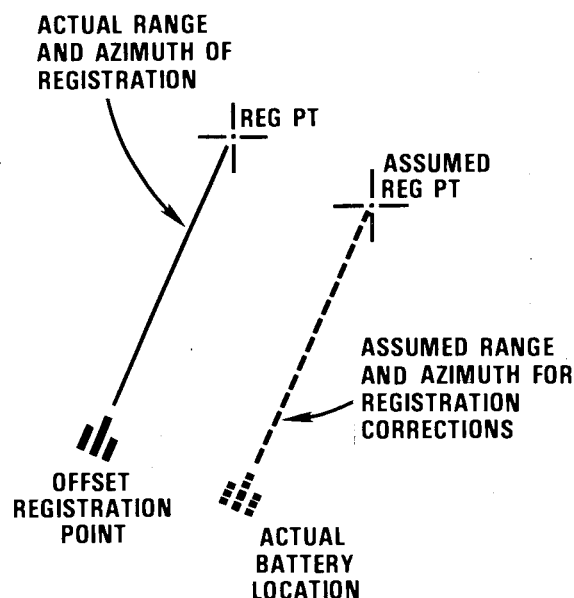


Figure 5-28. Transfer of registration data.

*c. Transfer Limits.* The transfer limits from the offset position must be inspected to insure that the registration corrections are valid for the battery's assigned zone of fire. If the entire zone is not within the transfer limits of the registration, additional GFT settings must be computed along additional azimuths using the eight-direction met technique to insure entire coverage of the assigned zone of fire.

### 5-33. Registrations to the Rear

A registration to the rear (or along some other azimuth significantly different from the primary azimuth of fire) may be either a precision or a high burst/MPI registration and may be abbreviated. The registration

will result in corrections but these corrections must be modified for the primary zone of fire using eight-direction met techniques. The actual area where the rounds will be bursting must be coordinated by the unit's S3 to insure there are no friendly units in the area.

### ★ 5-34. DPICM Registrations (M483A1/M509E1)

*a.* The dual-purpose ICM (DPICM) may be fired as a normal ICM round or as a registration round for other munitions like the area denial artillery munitions (ADAM) or remotely activated antitank mine system (RAAM). The round can be registered using either the precision or the high burst/mean point of impact method. Normally, the high burst method would be selected to conserve ammunition. The procedures are the same as those for a regular low angle HB registration with the following exceptions:

(1) A desired height of burst or at least 2 PEHB is added to the orienting point altitude for a high burst registration.

(2) Using either the M577 or M724 fuze, an adjusted time setting can be determined and used on the GFT setting.

*b.* Because of large vertical intervals, the FDO must consider the effects of comp site on the fuze setting and apply appropriate corrections listed in paragraph 5-19.

*c.* If a graze burst occurs on the first round, the trajectory should be modified by applying 2 PEHB (para 5-16).

*d.* If a point-detonating (PD) action is desired as for an MPI registration, both the M577 and M724 fuzes must be set for PD action.

*e.* In all cases, when the round is used in registrations, it must be prepared for the self-registration (SR) mode (expulsion charge removed and spotting charge attached to fuze). In the SR mode, the entire round will detonate and destroy the bomblets.

## Section VI. DETERMINATION AND APPLICATION OF REGISTRATION CORRECTIONS

### 5-35. Determining Registration Corrections

Registration corrections consist of a total range, total fuze, and total deflection correction. FDC personnel compute these corrections by comparing the chart, or "should hit" data (the data that would hit the target if standard conditions existed), with the adjusted or "did hit" data (that data that actually caused the round to hit the registration point or mean burst location).

#### a. Computation of Total Range Correction.

(1) If standard conditions existed, the elevation fired to achieve the chart range would be the elevation listed in the firing tables for that chart range. When nonstandard conditions exist, the range that is achieved by firing a certain elevation is greater or less than the range listed in the firing tables by an amount equal to all of the effects caused by the nonstandard conditions. This difference is the total range correction.

(2) The total range correction is the difference in meters between the initial chart range (or achieved range if there is base piece displacement) and the firing table range corresponding to the adjusted elevation. The total range correction is determined as follows:

(a) Determine, from the firing tables or the graphical firing table, the range to the nearest 10 meters corresponding to the adjusted elevation.

(b) Subtract the initial chart (or achieved) range from the range corresponding to the adjusted elevation. The result is the total range correction. The total range correction is always a signed value.

#### Example:

An M109A1 howitzer battery registered using charge 4GB. The base piece was over battery center. The initial chart range was 5000 meters and the adjusted elevation was 306.

1. Using the GFT, the range corresponding to the adjusted elevation of 306 is 5150 meters.

2. Subtracting the initial chart range from range corresponding to the adjusted elevation results in a total range correction of +150 meters ( $5150 - 5000 = +150$  meters).

3. This can be portrayed using part of the "lazy Z" (fig 5-29).

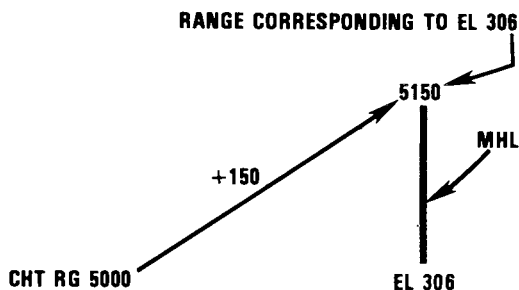


Figure 5-29. Range and elevation depicted on the lazy Z.

The difference between the initial chart range and the range corresponding to the adjusted elevation is +150. The total range correction is used in solving the concurrent met message.

#### b. Computation of Total Fuze Correction.

(1) The time portion of the precision registration or a high burst registration will result in an adjusted or "did hit" time (fuze setting). The time corresponding to the adjusted elevation is the "should hit" time that must be compared to the actual adjusted time determined by firing. The difference

between the time corresponding to the adjusted elevation and the adjusted time is the total fuze correction.

(2) The total fuze correction is determined by subtracting the time corresponding to the adjusted elevation (or elevation plus comp site if the vertical interval is greater than 100) from the adjusted time.

#### Example:

Continuing the example above, the battery obtained an adjusted time of 18.9.

The time corresponding to the adjusted elevation is 18.5.

The time corresponding to the adjusted elevation (18.5) is subtracted from the adjusted time (18.9) to determine a total fuze correction ( $18.9 - 18.5 = +0.4$ ).

This is portrayed using the other half of the "lazy Z" (fig 5-30).

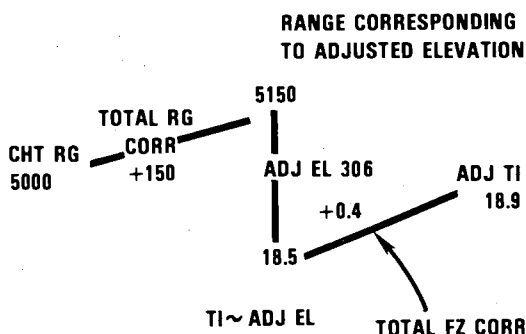


Figure 5-30. The lazy Z.

(3) The total fuze correction is used in solving the concurrent met message.

#### c. Computation of Total Deflection Correction.

(1) The total deflection correction is the correction in mils that must be added to the chart deflection in order to correct for all nonstandard conditions. The total deflection correction is determined on the Registration/Special Correction Worksheet.

(2) The total deflection correction is determined by subtracting the chart deflection from the adjusted deflection.

(3) A GFT deflection correction is determined by subtracting the drift corresponding to the adjusted elevation from the total deflection correction. The GFT deflection correction remains the same for all elevations fired with the registration charge. The total deflection correction changes by drift depending on the elevation being fired.

#### Example:

The battery had an initial chart deflection of 3165 and an adjusted deflection of 3173. The total deflection correction is L8. The drift corresponding to the adjusted elevation (306) (from the GFT) is L6. The GFT deflection correction is L2 (fig 5-31).

| REGISTRATION COMPUTATIONS |      |                                 |                       |     |       |
|---------------------------|------|---------------------------------|-----------------------|-----|-------|
|                           |      |                                 | DEFLECTION CORRECTION |     |       |
| (10M)                     | (8)  | Corr Df (Reg)                   |                       |     | (1pt) |
| (10M)                     | (5)  | BP Displ Corr (L + /R)          |                       |     | (1pt) |
| (10M)                     | (7)  | Adj Df ((8) + (5))              | 3173                  |     | (1pt) |
| (10M)                     | (8)  | Chart Df                        | 3165                  |     | (1pt) |
| (5M)                      | (9)  | Total Df Corr ((7) - (8) + L/R) | L8                    |     | (1pt) |
| (10M)                     | (6)  | Drift Corr (~ Adj El (L))       | L6                    |     | (1pt) |
| (1pt)                     | (11) | GFT Df Corr ((9) - (10))        | L2                    |     | (1pt) |
| Rg                        |      |                                 | EI                    | TI  |       |
| Rg                        |      |                                 | EI                    | TI  |       |
|                           |      |                                 | DEFLECTION CORRECTION |     |       |
|                           |      |                                 | Total                 | GFT |       |
|                           |      |                                 | L8                    | L2  |       |

Figure 5-31. Deflection correction.

(4) In some cases the adjusted deflection may require modification. The gunner may have had an incorrect sight picture or the piece may have registered prior to boresighting. In either case, the executive officer will report the correct adjusted deflection to the FDC. This adjusted deflection is then used to determine the total deflection correction.

#### 5-36. Graphical Firing Table Setting

The corrections determined by the registration are portrayed on the graphical firing table in the form of a GFT setting. The GFT setting may be:

A *one-plot* (only one set of registration corrections are available).

A *two-plot* (two different sets of registration corrections are available for the same charge).

A *multiplot* (more than two sets of registration corrections available).

The GFT setting is recorded on the Registration/Special Correction Worksheet and consists of the following items (in order):

Registering unit.

The charge fired in the registration.

Ammunition lot used in the registration.

Chart range (achieved range if there is piece displacement).

Adjusted elevation.

Adjusted time (if determined).

a. *One-Plot GFT Setting.* When corrections from only one registration (or one met + VE computation) are available, the corrections are shown on the GFT in the form of a one-plot GFT setting. See paragraph 4-6 for construction of a one-plot GFT setting.

b. *Two-Plot GFT Setting.*

(1) If two sets of registration corrections for the same weapon, same lot, and same charge are known, a more accurate GFT setting may be constructed. The two different sets of data may be from two separate registrations, two met + VE computations, or a combination of these items.

(2) The range to one of the points where the corrections are determined should be in

the upper third of the ranges shown on the GFT for the charge, and the range to the other point should be within the lower third of the ranges on the GFT for the charge.

*Example:*

For charge 4 the listed ranges on the GFT are from 1900 meters to 8000 meters. The lower third would be between 1900 meters and 3930 meters. The upper third would be between 5970 meters and 8000 meters.

(3) The construction of a two-plot GFT setting is discussed in paragraph 4-9.

c. *Multiplot GFT Settings.*

(1) Since at least three sets of current registration corrections for the same weapon, ammunition lot, and charge are required to construct a multiplot GFT setting, it rarely will be used. However, if the time and the situation permit the determination of three or more sets of corrections, the multiplot GFT setting will result in the most accurate determination of firing data. The corrections may be determined by registration, met + VE computations, or a combination of both.

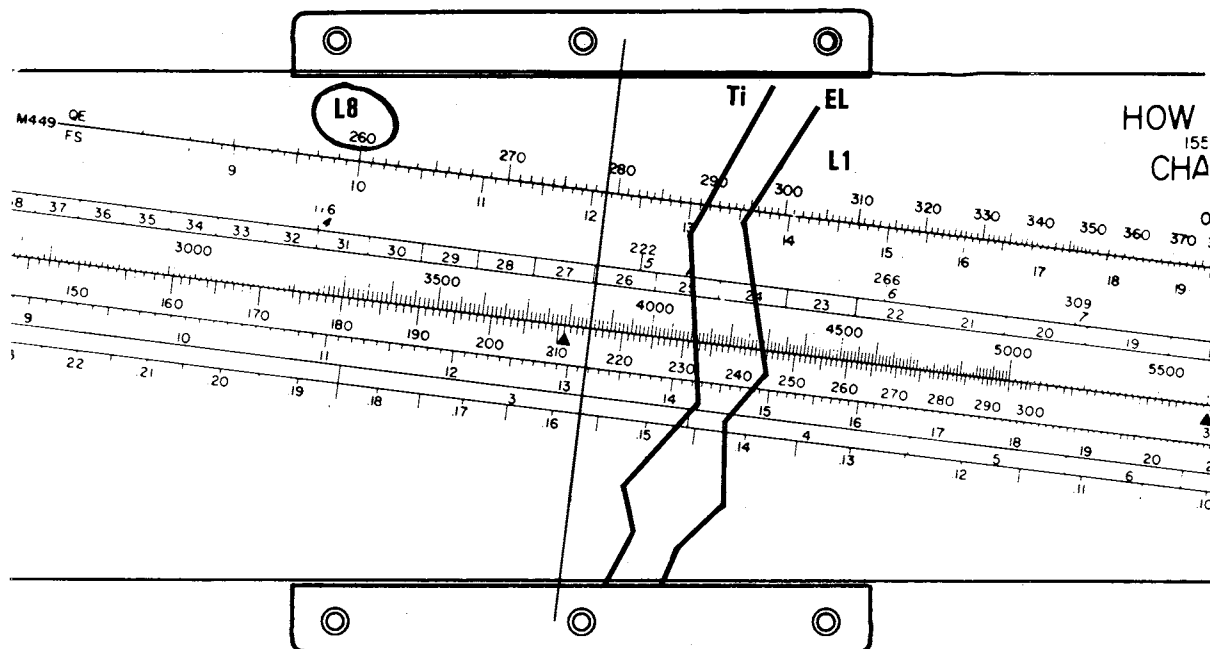


Figure 5-32. Multiplot GFT setting.



(2) The multiplot GFT setting is constructed in much the same manner as the two-plot GFT setting.

(a) Place the manufacturer's hairline over the chart range for the first set of corrections. Place a dot at the adjusted elevation and one over the adjusted time.

(b) Move the manufacturer's hairline over the chart range for the next set of corrections. Place a dot over the adjusted elevation and one over the adjusted time.

(c) Continue moving the manufacturer's hairline and plotting elevation and time dots until all of the corrections have been placed on the cursor.

(d) Each group of dots (the elevation dots and time dots) will be formed into gages by connecting the dots.

(3) The total and GFT deflection correction for the multiplot GFT setting is determined in the same manner as for the two-plot GFT setting:

(a) Determine the total deflection correction and GFT deflection correction for each set of data used to determine the multiplot GFT setting.

(b) Average the total deflection corrections and the GFT deflection corrections. The averages of these values are used as the total deflection correction and the GFT deflection correction for the multiplot GFT setting.

(4) A multiplot GFT setting would be similar to that shown in figure 5-32.

*d. Multiple Lot GFT Settings.* If the same charge has been used to conduct registrations of more than one lot of ammunition, two different GFT settings may be placed on the cursor or two GFTs or two cursors may be used. If the GFT setting is placed on the cursor using the procedures described above, it may be either marked with the letter designator for the applicable lot or drawn in a different color.

### ★ 5-37. Registration Transfer Limits

The corrections determined from a registration are valid only within certain range and deflection limits. The registration corrections for nonstandard conditions are valid only when firing toward the registration point. For example, when firing on a different azimuth, the wind will not affect the round in the same manner as it did along the azimuth to the registration point. Registration corrections are valid only for the position from which the registration was fired (except for offset registrations).

#### *a. Range Transfer Limits.*

(1) *One-plot GFT setting.* The range limits for a one-plot GFT setting are shown on the GFT. As long as the chart range of the registration point is between the leftmost and rightmost met checkpoints, the target is within the range transfer limits. The charge 4 GFT range limits are from range corresponding to elevation 150 (the first red-numbered elevation) to elevation 630 (the last red number on the elevation scale).

(2) *Two-plot GFT settings.* A two-plot GFT setting is valid only between the two ranges where the registration or reference points were conducted. The two-plot GFT setting is considered more valid than a one-plot GFT setting for elevations between the GFT setting ranges. At elevations not between these two ranges, the registration corrections tend to break down. Therefore, the two-plot GFT setting is not the preferred method.

(3) *Multiplot GFT settings.* The range limits for a multiplot GFT setting are eliminated whenever three or more sets of corrections are available for the same charge. When using the multiplot GFT setting, there are no range transfer limits.

#### *b. Deflection Transfer Limits.*

(1) The registration corrections are valid only within certain deflection transfer limits.

(2) When the chart range to a target is 10,000 meters or less, the deflection corrections are valid within an area 400 mils

left and 400 mils right of a line between the battery and the registration point (mean burst location) (fig 5-33).

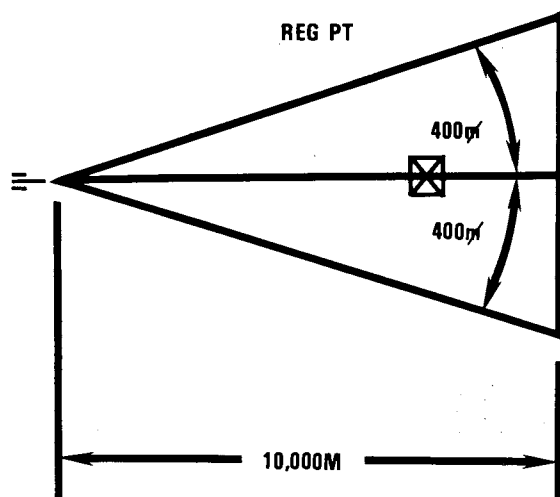


Figure 5-33. Deflection transfer limits.

(3) When the chart range to a target is greater than 10,000 meters, the registration corrections are valid within an area 4000 meters left and 4000 meters right of a line drawn between the battery and the registration point (mean burst location) (fig 5-34).

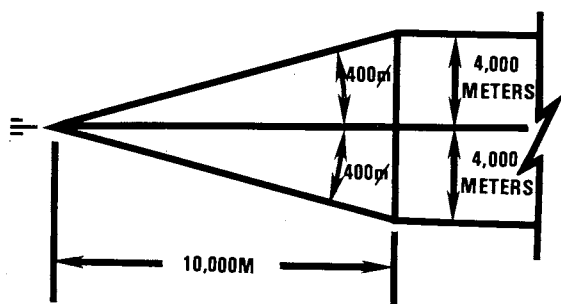


Figure 5-34. Valid area of registration corrections when range is greater than 10,000 meters.

(4) Registration corrections may be determined throughout the entire 6400 mils around the battery by using the eight-direction met technique.

### 5-38. Recomputation of GFT Settings

a. When a registration is conducted based on map spot data for the registration point and/or battery location, the correction determined will include corrections for map spot errors. Once survey data is available, the registration corrections need to be updated.

b. Manual recomputation of the GFT setting requires that the surveyed firing chart be constructed, and new chart data to the registration point be measured. Specifically, the chart range, deflection, and vertical interval are determined. The adjusted data remains the same. The correct chart data is then compared to the adjusted data to determine the corrected GFT setting.

(1) The new chart range becomes the new GFT setting range.

(2) Recompute site based on the new chart range and the correct vertical interval.

(3) Algebraically subtract the recomputed site from the adjusted quadrant elevation to determine the new adjusted elevation.

(4) Determine the new total deflection correction by comparing the new chart deflection to the adjusted deflection.

(5) Determine drift corresponding to the new adjusted elevation.

(6) Determine the new GFT deflection correction by algebraically subtracting the drift corresponding to the new adjusted elevation ((5) above) from the new total deflection correction ((4) above). The adjusted time will not change, as it was determined by firing, unless the initial vertical interval was less than 100 meters, and the corrected interval is greater than 100 meters. ("VI greater than 100 M" techniques must be used.) The adjusted deflection remains the same because the battery is not relaid.

*Example:*

## (1) Known map spot information and GFT setting:

|               |      |
|---------------|------|
| Adjusted df   | 3184 |
| Adjusted QE   | 432  |
| Adjusted ti   | 25.1 |
| Map spot site | +4   |

GFT B: Chg 4, Lot HG, Rg 6240, El 428, Ti 24.4. GFT Df Corr: L12

## (2) Survey information following construction of survey chart:

|                                       |      |
|---------------------------------------|------|
| Survey chart range                    | 6090 |
| Survey chart df                       | 3173 |
| Survey altitude of registration point | 364  |
| Survey altitude of battery            | 328  |

## (3) Solution:

## (a) Chart range 6090 becomes GFT range:

GFT B: Chg 4, Lot HG, Rg 6090 . . .

## (b) Recompute site:

|                             |     |
|-----------------------------|-----|
| Altitude registration point | 364 |
| - Altitude battery          | 328 |
| = Vertical interval         | +36 |

GST: Chg 4, TAG, Rg 6090 = site +7

## (c) Compute adjusted elevation:

|                      |       |
|----------------------|-------|
| Adjusted QE          | 432   |
| - Survey site        | -(+7) |
| = Adjusted elevation | 425   |

GFT B: Chg 4, Lot HG, Rg 6090, El 425, Ti 25.1.

Remember: Adjusted time does not change unless VI went from VI&lt;100 to VI&gt;100.

## (d) Determine GFT deflection correction:

|                     |       |
|---------------------|-------|
| Chart df            | 3173  |
| Adjusted df         | 3184  |
| Total correction    | L11   |
| - Drift (el 425)    | -(L)9 |
| = GFT df correction | L2    |

## (e) The complete GFT setting has now been recomputed:

GFT B: Chg 4, Lot HG, Rg 6090, El 425, Ti 25.1. GFT Df Corr: L2

## Section VII. REGISTRATION WITH FADAC

The FADAC can be used to determine firing data for all registration techniques. Chart range and deflection must still be determined

from the firing chart. When the computer is used to determine registration corrections, the resulting information is known as

FADAC residuals. FADAC residuals are the difference between what FADAC determines should have hit the registration point and what actually did hit the registration point after FADAC accounts for the effects of all the entered information. This "should hit" data includes the effects of many nonstandard conditions (met, muzzle velocity, propellant temperature, projectile weight, drift, and the rotation of the earth) that are not considered in manual computations. FADAC residuals, therefore, are more analogous to position corrections (see chapter 13) than to total corrections.

**5-39. FADAC Application of Residuals**

a. FADAC does not have the ability to store multiple corrections for each charge. The FADAC will only retain one set of registration corrections (residuals) for each charge. In addition, the FADAC will only retain and apply these corrections for one family of projectiles.

b. A family of projectiles are projectiles that have similar ballistic characteristics and travel from the gun to the target along similar trajectories. Shells HE, WP, gas, and HC smoke compose one family of projectiles. Residuals determined for shell HE will automatically be applied to any mission being conducted with the other three shells. The corrections will not be applied to other projectiles without operator action. See the FADAC User's Manual for a listing of each family of projectiles and specific instructions on appropriate procedures.

c. When only one battery has registered, the residuals determined may be used by the nonregistering batteries. This technique will be accurate when all batteries are surveyed and muzzle velocity information is current.

**5-40. Recomputing FADAC Residuals When Survey or Met Becomes Available**

a. FADAC registrations can be conducted using observed fire (OF) chart procedures, no current met message, and assumed battery and target locations. The registration corrections must be recomputed when a current met message is received and whenever the survey is completed.

b. The FADAC User's Manual outlines the specific actions to be taken to recompute the corrections. The items that do not change when recomputing the residuals are the adjusted values determined by the registration. The adjusted data is the firing data that actually hit the target and is based on the actual location of the battery, target, and nonstandard conditions that were present at the time of the registration.

**5-41. FADAC-Derived GFT Setting**

FADAC can be used to derive a GFT setting—single or multiplot. The accuracy of this GFT setting should approach that of a registration if all nonstandard conditions are known. Derived GFT settings should always be used in place of "cold stick" data as they will compensate for earth rotation, projectile weight, muzzle velocity, and propellant temperature.

# CHAPTER 6

## MET

### Section I. INTRODUCTION

#### 6-1. Nonstandard Conditions

a. To place accurate surprise fires on targets of known location, it is necessary to apply corrections to firing table data to compensate for the effects of nonstandard conditions. The most accurate means of determining these corrections is from a current registration. Many times a registration to determine current corrections is prohibited or not feasible. In such cases, approximate corrections can be determined by measuring deviations from standard conditions and computing corrections for these deviations. The techniques used to measure deviations from standard and compute corrections for them are called met.

b. The firing tables used to produce firing data for artillery cannons are based on an arbitrary set of standard conditions for weather, position, and materiel. To gain a better understanding of the gunnery problem and artillery meteorological procedures, it is necessary to know the standard conditions upon which the firing tables and FADAC are based. It is apparent that some variations to the standard conditions are quite appreciable and easy to measure. Such conditions include air temperature, air density, wind direction and speed, propellant temperature, projectile weight, VI, Earth rotation, and drift. Additional variations also exist that are often negligible in effect and quite difficult to

measure precisely, such as position survey and firing chart tolerances, boresight inaccuracies, and weapon lay. Variations from these standards create nonstandard conditions that must be corrected for by either registration or computation. The computations performed in the FDC to compensate for nonstandard conditions are done on a Met Data Correction Sheet, DA Form 4200. There are two techniques used to solve mets: concurrent met and subsequent met.

#### 6-2. Concurrent Met

a. A concurrent met is solved to separate the total corrections determined by a registration into two component parts: those elements that can be easily measured and corrected, MET CORRECTIONS, and those that cannot be easily measured and corrected, POSITION CORRECTIONS. The total corrections for range, fuze setting, and deflection are caused by the total variations from standard conditions of weather, position, and materiel existing at the time of registration. Weather information is provided to artillery units by artillery met sections in the format of a met message. To successfully use the concurrent met technique, it is important that the registration be fired very close to the same time that the met section is measuring the actual weather conditions.

$$\text{TOTAL CORRECTIONS} = \text{MET CORRECTIONS} + \text{POSITION CORRECTIONS}$$

b. If a registration is fired at the same time the met section is measuring the existing weather conditions, it is possible to determine the amount of the total corrections due to nonstandard weather conditions. When the registration is fired, the effects of wind, air temperature, and air density; the projectile weight and propellant temperature of the lot fired; the difference in altitude between the gun and the target; the drift at the registration point range; and the effects of

corrections due to met to isolate position corrections that are considered constant.

### 6-3. Subsequent Met

a. Since met corrections are variable, and easily measured and corrected, they can be measured at any time and corrections

$$\begin{array}{ccccccc} \text{Total corrections} & = & \text{met corrections} & + & \text{position corrections} \\ & & \text{(variable)} & & \text{(constant)} \end{array}$$

earth rotation on both range and deflection can all be determined. All of these nonstandard conditions are easy to measure and correct for, and are conveniently grouped together under the heading *met corrections* (variable). The nonstandard conditions that cannot be measured are called *position corrections* and are usually small in magnitude, difficult to measure, and relatively constant. When all the variable nonstandard conditions have been measured and corrections computed, it is then possible to subtract the met (variable) corrections from the total corrections and identify the amount of position (constant) nonstandard conditions.

computed. After a registration has been conducted, the concurrent met solved, and position constants isolated, it may be unnecessary to register again from that position. Met messages received after the concurrent met are termed subsequent mets. New total corrections, and thus new GFT settings, can be determined using the subsequent met technique.

b. The subsequent met technique is used to produce a current GFT setting when a subsequent registration is not possible. A subsequent met is solved using a Met Data Correction Sheet, DA Form 4200. Other applications of the subsequent met technique are:

$$\text{Total corrections} - \text{met corrections} = \text{position corrections.}$$

The concurrent met technique starts with total range, total fuze, and total deflection correction from a registration and subtracts the portion of those

- (1) Eight-direction met.
- (2) Met to a target.
- (3) Met to a met check gagepoint.

$$\begin{array}{ccccccc} \text{New met corrections} & + & \text{old position corrections} & = & \text{new total corrections} \\ \text{(new variables)} & & \text{(constant)} & & \end{array}$$

## Section II. MET MESSAGES

To correct for nonstandard conditions caused by weather, nonstandard conditions must be measured. This is done by the artillery met section, normally located at each division artillery and FA brigade headquarters. One of its jobs is to sample the weather at various altitudes by releasing a balloon with a transmitter (called a radiosonde) attached. As the balloon gains altitude, the radiosonde transmits necessary data to a ground receiver. This data is converted, manually or by computer, to give specific weather information at specific altitudes. This weather data is transmitted to the artillery units in a fixed format called a met message.

- ★ This format consists of the introduction that identifies the type of met message, the time it was flown, the altitude of the met station, and the atmospheric pressure at the met station. The body contains weather information at specific altitudes. There are three types of met messages (ballistic (B), computer (CM), and fallout (F)) used by the field artillery. The fallout message is used in nuclear and chemical fallout predictions and will not be discussed here.

### 6-4. Ballistic Meteorological Message

a. The ballistic met message is a coded message containing information about current atmospheric conditions. Two types of ballistic met messages are provided for artillery fire. The type 2 message is used in air defense artillery. The type 3 message is used by field artillery cannon and field artillery rocket units for firing at surface targets and is the type used in solving the Met Data Correction Sheet. The introductory portion of the firing tables for each weapon specifies which type of met message is to be used for the weapon; e.g., paragraph 10D, page XXVII, FT 155-AM-1, states that type 3 messages will be used at all elevations of all charges for the M109A1 howitzer.

### INTRODUCTION

**MET B31 (GROUP 1) 345982 (GROUP 2)**  
**270950 (GROUP 3) 037991 (GROUP 4)**

### BODY

|               |               |
|---------------|---------------|
| <b>002107</b> | <b>029957</b> |
| <b>012208</b> | <b>029954</b> |
| <b>022309</b> | <b>033954</b> |
| <b>032410</b> | <b>037954</b> |
| <b>042610</b> | <b>039956</b> |
| <b>052812</b> | <b>042957</b> |

Figure 6-1. Ballistic met message.

b. The ballistic met message is divided into an introduction and a body (fig 6-1).

(1) The introduction to the ballistic met message consists of four six-character groups.

(a) *Group 1.* The first three letters (MET) in group 1 designate the transmission as a met message. The next letter (B) indicates that it is a ballistic met message. The first digit (3) indicates the type of met message. The last digit (1) designates the octant of the earth in which the met station is located. In this case, 1 designates that the met station is between 90° W and 180° W longitude and that it is north of the Equator (north latitude) (fig 6-2). Table 6-1 is the key to the octant code.

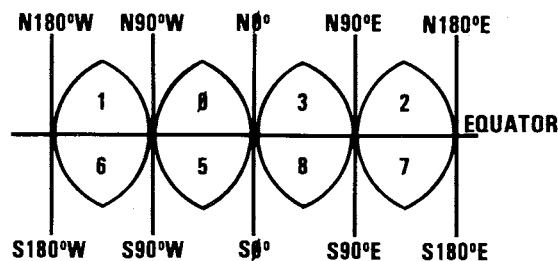


Figure 6-2. Octant code.

## Code number

|        |                                             |
|--------|---------------------------------------------|
| 0..... | North latitude, 0° to 90° west longitude.   |
| 1..... | North latitude, 90° to 180° west longitude. |
| 2..... | North latitude, 180° to 90° east longitude. |
| 3..... | North latitude, 90° to 0° east longitude.   |
| 4..... | Not used.                                   |
| 5..... | South latitude, 0° to 90° west longitude.   |
| 6..... | South latitude, 90° to 180° west longitude. |
| 7..... | South latitude, 180° to 90° east longitude. |
| 8..... | South latitude, 90° to 0° east longitude.   |
| 9..... | Used for coded identification.              |

(b) *Group 2.* Group 2 designates the center of the area in which the met message is valid. This is expressed in tens, units, and tenths of degrees of latitude and longitude (345 = 34.5° = 34°30' north latitude, and 982 = 98.2° = 98.12' west longitude), or when the number 9 is used to designate the octant, the six digits or letters represent the coded location of the met station that produced the message.

(c) *Group 3.* The first two digits (27) in group 3 represent the day of the month the met message is valid. The next three digits (095) indicate the hour, in tens, units, and tenths of hours (095 = 09.5 hrs = 0930) the met message becomes valid. The hours refer to Greenwich mean time. The last digit (0) in group 3 indicates the number of hours the message will remain valid. The United States does not attempt to predict the length of time a met message will remain valid; instead, during combat, the United States normally obtains new met data on a 2-hour schedule. Therefore, the last digit in group 3 of a ballistic met message produced by the United States will always be 0. Some Allied Nations predict the length of time a met message will remain valid. These predictions vary from 1 to 8 hours. Code figure 9 indicates 12 hours.

(d) *Group 4.* The first three digits (037) of group 4 indicate the altitude of the met station (meteorological datum plane (MDP)) above mean sea level in multiples of 10 meters (037 = 370 meters). The next three digits (991)

indicate the atmospheric pressure at the MDP, expressed as a percentage (to the nearest 0.1 percent) of the International Civil Aviation Organization (ICAO) standard atmosphere pressure at mean sea level (991 = 99.1 percent). When a value is greater than 100 percent, the initial digit 1 is omitted.

(2) The body of the met message can consist of 16 met message lines (00 through 15), each line consisting of two six-number groups. Each line contains the ballistic weather for a particular altitude zone. Ballistic data is a weighted average of the conditions that exist from the surface up through the altitude zone indicated by the line number and back to the surface (fig 6-3).

(a) The first two numbers (03) of group 1 indicate the met line number that identifies the altitude zone. The lines are numbered in

| ZONE<br>HEIGHT (M) | LINE<br>NUMBER |
|--------------------|----------------|
| SURFACE            | 00             |
| 200                | 01             |
| 500                | 02             |
| 1000               | 03             |
| 1500               | 04             |
| 16000              | 14             |
| 18000              | 15             |

Figure 6-3. Zone altitude.



sequence from 00 (surface conditions) through 15 (18,000 meters). Line number 03 is used as an example.

(b) The next two digits (24) in this group indicate from which direction the ballistic wind is blowing, expressed in hundreds of mils true azimuth (24 = 2400 mils).

(c) The last two digits (10) in group 1 indicate the speed of the ballistic wind in knots (10 = 10 knots).

(d) The first three digits (037) of the second group indicate the ballistic air temperature, expressed as a percentage (to the nearest 0.1 percent) of the ICAO standard temperature (037 = 103.7 percent). When a value is greater than 100 percent, for temperature or pressure, the initial digit 1 is omitted.

(e) The last three digits (954) of this group indicate the ballistic air density expressed as a percentage (to the nearest 0.1 percent) of the ICAO standard density (954 = 95.4 percent).

c. To assist in the use and recording of the message, DA Form 3075, Ballistic Met Message, is used (fig 6-4).

## 6-5. Computer Meteorological Message

The computer met message, like the ballistic met message, is a coded message that reports the atmospheric conditions in selected layers starting at the surface and extending to an altitude that will normally include the maximum ordinate of field artillery weapons that use this data. Unlike the ballistic met message used in the manual computations (where the weather conditions existing in one layer or zone are weighted against the conditions in lower layers and reported as percentages of the standard), the computer met reports actual average windspeed, air temperature, and pressure in each layer. The computer met message is used by the FADAC and TACFIRE computers in the computation of the equations of motion used in the computer's program.

a. The computer met message is divided into an introduction and a body (fig 6-5).

(1) The introduction to the computer met consists of four six-character groups.

(a) *Group 1.* The first five letters (METCM) designate the transmission as a computer met message. The last figure (digit

| BALLISTIC MET MESSAGE                                                                             |                |                           |                                                                                                                           |                            |                                                            |                       |                                |                                |  |
|---------------------------------------------------------------------------------------------------|----------------|---------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------------------------------|-----------------------|--------------------------------|--------------------------------|--|
| For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command |                |                           |                                                                                                                           |                            |                                                            |                       |                                |                                |  |
| IDENTIFICATION                                                                                    | TYPE MSG       | OCTANT                    | LOCATION<br>L <sub>1</sub> L <sub>2</sub> L <sub>3</sub> L <sub>4</sub> L <sub>5</sub> L <sub>6</sub><br>or<br>xxx or xxx | DATE<br>YY                 | TIME (GMT)<br>G <sub>0</sub> G <sub>1</sub> G <sub>2</sub> | DURATION (HOURS)<br>G | STATION HEIGHT (10's M)<br>hhh | MDP PRESSURE (% OF STD)<br>PPP |  |
| METB                                                                                              | K              | Q                         |                                                                                                                           |                            |                                                            |                       |                                |                                |  |
| METB                                                                                              | 3              | 1                         | 344 983                                                                                                                   | 13                         | 045                                                        | 0                     | 036                            | 983                            |  |
|                                                                                                   |                | BALLISTIC WINDS           |                                                                                                                           |                            |                                                            | BALLISTIC AIR         |                                |                                |  |
| ZONE HEIGHT (METERS)                                                                              | LINE NUMBER ZZ | DIRECTION (100's MILS) dd | SPEED (KNOTS) FF                                                                                                          | TEMPERATURE (% OF STD) TTT | DENSITY (% OF STD) ΔΔΔ                                     |                       |                                |                                |  |
| SURFACE                                                                                           | 00             | 27                        | 13                                                                                                                        | 033                        | 996                                                        |                       |                                |                                |  |
| 200                                                                                               | 01             | 29                        | 15                                                                                                                        | 035                        | 998                                                        |                       |                                |                                |  |
| 500                                                                                               | 02             | 32                        | 15                                                                                                                        | 042                        | 993                                                        |                       |                                |                                |  |
| 1000                                                                                              | 03             | 33                        | 17                                                                                                                        | 040                        | 991                                                        |                       |                                |                                |  |
| 1500                                                                                              | 04             | 35                        | 21                                                                                                                        | 039                        | 990                                                        |                       |                                |                                |  |
| 16000                                                                                             | 14             |                           |                                                                                                                           |                            |                                                            |                       |                                |                                |  |
| 18000                                                                                             | 15             |                           |                                                                                                                           |                            |                                                            |                       |                                |                                |  |

DA FORM 3075  
JAN 71 3675

REPLACES DA FORM 6-57, 1 MAR 62, WHICH IS OBSOLETE.

Figure 6-4. Ballistic Met Message

## COMPUTER MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command

| IDENTIFICATION<br>METCM    | OCTANT<br>Q          | LOCATION<br>L <sub>a</sub> L <sub>a</sub> L <sub>a</sub> L <sub>o</sub> L <sub>o</sub> L <sub>o</sub><br>or<br>xxx or<br>xxx | DATE<br>YY                      | TIME<br>(GMT)<br>G <sub>o</sub> G <sub>o</sub> G <sub>o</sub> | DURATION<br>(HOURS)<br>G        | STATION<br>HEIGHT<br>(10's M)<br>hhh | MOP<br>PRESSURE<br>MB's<br>P <sub>d</sub> P <sub>d</sub> P <sub>d</sub> |
|----------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------------------------------------|---------------------------------|--------------------------------------|-------------------------------------------------------------------------|
| METCM                      | 1                    | 512 018                                                                                                                      | 07                              | 095                                                           | 0                               | Q49                                  | 987                                                                     |
| ZONE VALUES                |                      |                                                                                                                              |                                 |                                                               |                                 |                                      |                                                                         |
| ZONE<br>HEIGHT<br>(METERS) | LINE<br>NUMBER<br>ZZ | WIND<br>DIRECTION<br>(10's M)<br>ddd                                                                                         | WIND<br>SPEED<br>(KNOTS)<br>FFF | TEMPERATURE<br>(1/10°K)<br>TTTT                               | PRESSURE<br>(MILLIBARS)<br>PPPP |                                      |                                                                         |
| SURFACE                    | 00                   | 260                                                                                                                          | 018                             | 2698                                                          | 0987                            |                                      |                                                                         |
| 200                        | 01                   | 220                                                                                                                          | 018                             | 2689                                                          | 0974                            |                                      |                                                                         |
| 500                        | 02                   | 270                                                                                                                          | 022                             | 2674                                                          | 0955                            |                                      |                                                                         |
| 1000                       | 03                   | 300                                                                                                                          | 025                             | 2660                                                          | 0900                            |                                      |                                                                         |
| 1500                       | 04                   | 310                                                                                                                          | 030                             | 2651                                                          | 0848                            |                                      |                                                                         |
| 19000                      | 25                   |                                                                                                                              |                                 |                                                               |                                 |                                      |                                                                         |
| 20000                      | 26                   |                                                                                                                              |                                 |                                                               |                                 |                                      |                                                                         |
| FROM<br>TO                 |                      |                                                                                                                              | DATE & TIME (GMT)               |                                                               | DATE & TIME (LST)               |                                      |                                                                         |
| MESSAGE NUMBER             |                      |                                                                                                                              | RECORDER                        |                                                               | CHECKED                         |                                      |                                                                         |

DA FORM 3677  
JAN 71

REPLACES DA FORM 6-59, 1 MAR 62, WHICH IS OBSOLETE.

Figure 6-5. Computer met message.

1) is the designation of the octant of the Earth in which the station is located. The octant code key is the same as for the ballistic met.

(b) *Group 2.* Group 2 is the same as group 2 in the ballistic met.

(c) *Group 3.* Group 3 is the same as group 3 in the ballistic met.

(d) *Group 4.* The first three digits (049) of group 4 indicate the altitude of the met station meteorological datum plane above mean sea level in tens of meters (490). The last three digits (987) indicate the atmospheric pressure in millibars at the met station. When the value is greater than 1000, the first digit 1 is omitted; e.g., 009 = 1009.

(2) The body of the met message consists of 27 met message lines (00 through 26), each line consisting of two eight-number groups. Each line contains the actual average weather data for a particular altitude zone.

(a) The first two digits of the first group

indicate the met line number that identifies the zone. The lines are numbered in sequence from 00 (surface conditions) through 26. Line 00 is used as an example.

(b) The next three digits (260) indicate the direction from which the wind is blowing expressed to tens of mils (2600) true azimuth.

(c) The last three digits (018) indicate the windspeed expressed in knots.

(d) The first four digits of the second group indicate the actual air temperature expressed in degrees Kelvin to the nearest tenth of a degree (269.8° Kelvin).

(e) The last four digits of the second group indicate the actual air pressure in millibars (0987) to the nearest millibar.

b. DA Form 3677, Computer Met Message, is used to record the computer met.

## 6-6. Met Message Errors

When the met message is received by the

FDC, it should be checked to insure that it is correct. The validity of the met message should be questioned if any of the following conditions appear.

*a. Ballistic Met (fig 6-6).*

(1) Drastic changes (over 1000 miles) or sudden reverses of wind direction from line to line; ballistic winds should flow in a fairly uniform manner.

(2) Severe increases or decreases (10 to 15 knots) in windspeed from line to line.

(3) Temperature and density changing in the same direction; as temperature increases, density should decrease.

(4) Drastic changes (2 percent or more) in density or temperature; ballistic temperature and density should change smoothly between zones.

(5) Gross differences in position constants from registration to registration.

(6) Large changes in recorded quantities unless weather conditions have changed.

*b. Computer Met (fig 6-7).*

(1) Drastic wind direction changes (over 1000 miles) or sudden reverses in wind direction from line to line.

(2) Abrupt increases or decreases (10 to 15 knots) in windspeeds.

(3) Difference in identification line pressure and surface pressure.

(4) Increase in pressure; pressure should decrease smoothly from line to line. Pressure will never increase with height.

(5) Severe increase or decrease (over 20° Kelvin) in temperature.

**6-7. Met Message Space and Time Validity**

*a. Space Considerations.* The accuracy of a met message may decrease as the distance from the meteorological sounding site increases. Local topography has a pronounced effect on the distance that met data can be reasonably extended. In

| BALLISTIC MET MESSAGE                                                                             |                |                           |                                                                                                                              |                            |                                                            |                       |                                |                              |
|---------------------------------------------------------------------------------------------------|----------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------------------------------|-----------------------|--------------------------------|------------------------------|
| For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command |                |                           |                                                                                                                              |                            |                                                            |                       |                                |                              |
| IDENTIFICATION                                                                                    | TYPE MSG       | OCTANT                    | LOCATION<br>L <sub>a</sub> L <sub>a</sub> L <sub>a</sub> L <sub>o</sub> L <sub>o</sub> L <sub>o</sub><br>or<br>xxx or<br>xxx | DATE<br>YY                 | TIME (GMT)<br>G <sub>0</sub> G <sub>0</sub> G <sub>0</sub> | DURATION (HOURS)<br>G | STATION HEIGHT (10's M)<br>hhh | MDP PRESSURE % OF STD<br>PPP |
| METB                                                                                              | K              | Q                         |                                                                                                                              |                            |                                                            |                       |                                |                              |
| METB                                                                                              | 3              | 1                         | 625 468                                                                                                                      | 29                         | 025                                                        | 0                     | 025                            | 001                          |
|                                                                                                   |                | BALLISTIC WINDS           |                                                                                                                              |                            | BALLISTIC AIR                                              |                       |                                |                              |
| ZONE HEIGHT (METERS)                                                                              | LINE NUMBER ZZ | DIRECTION (100's MILS) dd | SPEED (KNOTS) FF                                                                                                             | TEMPERATURE (% OF STD) TTT | DENSITY (% OF STD) ΔΔΔ                                     |                       |                                |                              |
| SURFACE                                                                                           | 00             | 31                        | 04                                                                                                                           | 052                        | 902                                                        |                       |                                |                              |
| 200                                                                                               | 01             | 25                        | 13                                                                                                                           | 048                        | 907                                                        |                       |                                |                              |
| 500                                                                                               | 02             | 30                        | 12                                                                                                                           | 040                        | 914                                                        |                       |                                |                              |
| 1000                                                                                              | 03             | 64                        | 12                                                                                                                           | 019                        | 920                                                        |                       |                                |                              |
| 1500                                                                                              | 04             | 34                        | 13                                                                                                                           | 032                        | 922                                                        |                       |                                |                              |
| 2000                                                                                              | 05             | 36                        | 31                                                                                                                           | 024                        | 911                                                        |                       |                                |                              |
| 3000                                                                                              | 06             |                           |                                                                                                                              |                            |                                                            |                       |                                |                              |
| 4000                                                                                              | 07             | OVER 1000                 | OVER 15 KNOTS                                                                                                                | OVER 2%                    | BOTH DECREASING                                            |                       |                                |                              |
| 5000                                                                                              | 08             |                           |                                                                                                                              |                            |                                                            |                       |                                |                              |

Figure 6-6. Ballistic met message (errors).

## COMPUTER MET MESSAGE

For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command

| IDENTIFICATION<br>METCM    | OCTANT<br>Q          | LOCATION<br>LaLaLa LoLoLo<br>or<br>xxx or<br>xxx | DATE<br>YY                      | TIME<br>(GMT)<br>GoGoGo         | DURATION<br>(HOURS)<br>G        | STATION<br>HEIGHT<br>(10's M)<br>hhh | MDP<br>PRESSURE<br>MB's<br>PdPdPd |
|----------------------------|----------------------|--------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------------------------------------|-----------------------------------|
| METCM                      | 1                    | 344 982                                          | 17                              | 175                             | 0                               | 036                                  | 966                               |
| ZONE VALUES                |                      |                                                  |                                 |                                 |                                 |                                      |                                   |
| ZONE<br>HEIGHT<br>(METERS) | LINE<br>NUMBER<br>ZZ | WIND<br>DIRECTION<br>(10's M)<br>ddd             | WIND<br>SPEED<br>(KNOTS)<br>FFF | TEMPERATURE<br>(1/10°K)<br>TTTT | PRESSURE<br>(MILLIBARS)<br>PPPP |                                      |                                   |
| SURFACE                    | 00                   | 310                                              | 004                             | 3030                            | 0966                            |                                      |                                   |
| 200                        | 01                   | 249                                              | 013                             | 3012                            | 0953                            |                                      |                                   |
| 500                        | 02                   | 316                                              | 012                             | 2966                            | 0928                            |                                      |                                   |
| 1000                       | 03                   | 503                                              | 013                             | 3199                            | 0886                            |                                      |                                   |
| 1500                       | 04                   | 371                                              | 101                             | 2882                            | 0888                            |                                      |                                   |
| 2000                       | 05                   | 455                                              | 015                             | 2762                            |                                 |                                      |                                   |
| 2500                       | 06                   |                                                  |                                 |                                 |                                 |                                      |                                   |
| 3000                       | 07                   | OVER 1000 ft                                     | 101 KNOTS, OBVIOUS              | DRASTIC CHANGE                  | PRESSURE INCREASE               |                                      |                                   |
| 3500                       | 08                   |                                                  | ERROR                           |                                 |                                 |                                      |                                   |

Figure 6-7. Computer met message (errors).

mountainous terrain, distinct variations of wind occur over short distances. This effect extends to much greater heights than the mountain tops. Large bodies of water will affect both the time and space considerations of the met message due to the land and sea breezes and the effect of humidity on density (increases in humidity decrease air density). It would be impossible to compute an exact distance for every combination of weather and terrain that might exist. Met messages for artillery are considered valid up to 20 km from the balloon release point to the trajectory midpoint over gently rolling terrain. The validity distance decreases proportionately with the roughness of the terrain.

*b. Time Consideration.* The passage of time may decrease the accuracy of a message because of the changing nature of weather. With the present equipment, it is extremely difficult for the artillery met section to provide met messages more frequently than every 2 hours over an extended period of time.

There are no specific rules for determining the usable time, since that determination will depend on the characteristics of the atmosphere, periods of transition, met section movement, personnel, supplies and equipment, and the altitude of the met message (line number) required by the artillery firing units. When the weather pattern is variable, the usable time is variable. If a frontal passage is forecast for the area, the met section will take a new sounding after the passage of the front. When the weather pattern is stable, and is forecast to remain so, time between messages may be extended up to several hours or longer, depending on the time of day and existing weather conditions.

*c. Criteria for Use of Meteorological Data.* Results of many studies based on artillery firing and meteorological data show that the order of preference of various sources of met data is as follows: (A current met message is one that is less than 2 hours old unless an exchange of airmass has occurred since the

met message was produced or unless periods of transition are involved.)

(1) Current met message from a station within 20 kilometers of the midpoint of the trajectory (upwind best).

(2) Current met message from the

nearest station more than 20 kilometers from the midpoint of the trajectory (upwind best).

(3) Met messages over 2 hours old but from a station within 20 kilometers of the midpoint of the trajectory. A 4-hour old met message may be used except when day/night transitions or frontal passages are occurring.

## Section III. CONCURRENT MET

A concurrent met is solved to determine position constants. Met corrections are determined, then subtracted from the total corrections to yield position constants. The recommended sequence for solving a concurrent met is to follow the sequence of the tables. This recommended sequence is outlined in paragraph 6-8.

### 6-8. Sequence for Solution of a Concurrent Met

a. Determine and enter total corrections from the GFT setting.

b. Enter known data.

c. Determine met line number from table A.

d. Enter met message data.

e. Compute  $\Delta h$ , height of target above gun, chart direction of wind.

f. Enter TFT and determine:

(1) Comp range from table B.

(2) Wind components from table C.

(3) Corrections to temperature and density from table D.

(4) Correction to muzzle velocity for propellant temperature from table E.

g. Compute corrected values for

temperature, density, entry range, crosswind, rangewind, and variations from standard.

h. Enter TFT and determine:

(1) Unit corrections from table F.

(2) Rotation corrections for range from table H.

(3) Rotation corrections for azimuth from table I.

i. Compute met deflection correction and position deflection correction.

j. Compute met range correction and position VE.

k. Enter variations from standard in Met Fuze Correction block and determine unit corrections from table J.

l. Compute met fuze correction and position fuze correction.

### 6-9. Solution of a Concurrent Met

a. The following known data is given:

(1) From the registration:

GFT A: Chg 4, Lot XY, Rg 5030, El 304,  
Ti 18.7

Adj df 3157

Cht df 3159

Adj QE 316  
Dir of fire 651

(2) From the executive officer:  
Projectile weight 3  $\square$   
Propellant temperature +82° F.

(3) From a map or firing chart:  
Altitude of registration point 389  
Altitude of battery 336  
Latitude 30° N

(4) From met station:  
METB31 347985 271250 055972  
005816 010958  
015816 010960

025917 008958  
036021 004960  
046023 002959

b. Determine and enter the total corrections from the GFT setting. Total corrections are determined as described in paragraph 5-35.

c. Enter known data. The known data is then entered (fig 6-8). Data entered consists of the charge, adjusted QE, chart range, latitude (nearest 10°), battery altitude (nearest meter and nearest 10 meters), target altitude, direction of fire (nearest mil and nearest 100 mils), projectile weight, and propellant temperature.

| MET DATA CORRECTION SHEET                                     |              |                 |                          |                        |             |                 |           |             |  |
|---------------------------------------------------------------|--------------|-----------------|--------------------------|------------------------|-------------|-----------------|-----------|-------------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                 |                          |                        |             |                 |           |             |  |
| BATTERY DATA                                                  |              |                 |                          |                        | MET MESSAGE |                 |           |             |  |
| CHARGE                                                        | ADJ QE       | CHART RG        | LATITUDE                 | TYPE MESSAGE           | OCTANT      |                 | AREA/UNIT |             |  |
| 428                                                           | 316          | 5030            | 30°N                     |                        |             |                 |           |             |  |
| ALT OF BTRY (10m)                                             |              | 340             |                          | DATE                   | TIME        | ALT MDP         |           | PRESSURE    |  |
| ALT OF MDP                                                    |              |                 |                          | LINE NO.               | WIND DIR    | WIND SPEED      | AIR TEMP  | AIR DENSITY |  |
| BTRY ABOVE MDP (Δh)                                           |              |                 |                          | Δh CORRECTION          |             | ±               |           | ±           |  |
| ALT OF TARGET (nearest meter)                                 |              | 389             |                          | CORRECTED VALUES       |             |                 |           |             |  |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                 |                          |                        |             |                 |           |             |  |
| ALT OF BURST                                                  |              |                 |                          |                        |             |                 |           |             |  |
| ALT OF BTRY (nearest meter)                                   |              | 336             |                          |                        |             |                 |           |             |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              |                 |                          | COMP RG                | CHART RG    | 5030            | ENTRY RG  |             |  |
| WIND COMPONENTS AND DEFLECTION                                |              |                 |                          |                        |             |                 |           |             |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400            |                          |                        |             |                 |           |             |  |
| DIRECTION OF WIND                                             |              |                 |                          |                        |             |                 |           |             |  |
| (651)                                                         |              |                 |                          |                        |             |                 |           |             |  |
| DIRECTION OF FIRE                                             |              | 700             |                          |                        |             |                 |           |             |  |
| CHART DIRECTION OF WIND                                       |              |                 |                          |                        |             |                 |           |             |  |
| CROSS WIND                                                    | WIND SPEED   | L               | COMP R                   | =                      | R           | KNOTS           | ×         | UNIT CORR   |  |
| RANGE WIND                                                    | WIND SPEED   | T               | COMP H                   | =                      | TAIL HEAD   | KNOTS           |           |             |  |
| ROTATION CORR                                                 |              | L               |                          | R                      |             | CROSS WIND CORR |           | L           |  |
| DRIFT CORR                                                    |              | L               |                          | R                      |             | MET DEFL CORR   |           | L           |  |
| MET RANGE CORRECTION                                          |              |                 |                          |                        |             |                 |           |             |  |
|                                                               | KNOWN VALUES | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS       | PLUS        | MINUS           |           |             |  |
| RANGE WIND                                                    | T            | 0               | T                        |                        |             |                 |           |             |  |
| AIR TEMP                                                      |              | 100%            | D                        |                        |             |                 |           |             |  |
| AIR DENSITY                                                   |              | 100%            | D                        |                        |             |                 |           |             |  |
| PROJ WEIGHT                                                   | 3 $\square$  |                 | D                        |                        |             |                 |           |             |  |
| ROTATION                                                      |              |                 |                          |                        |             |                 |           |             |  |
| MET RANGE CORR                                                |              |                 |                          |                        |             |                 |           |             |  |
| COMPUTATION OF VE                                             |              |                 |                          |                        |             |                 |           |             |  |
| PROP TEMP                                                     | +82          | VE              | M/S                      | TOTAL RANGE CORRECTION |             |                 |           |             |  |
|                                                               |              | CHARGE MV       | M/S                      | TOTAL VE CORRECTION    |             |                 |           |             |  |
| + NEW FZ CORR                                                 |              |                 |                          | ±2-AVG FZ CORR         |             |                 |           |             |  |
| BTRY NO.                                                      |              | BATTERY         |                          | DATE/TIME              |             |                 |           |             |  |

DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

Figure 6-8. Known data and GFT setting.

- ★ d. Determine met line number from table A (fig 6-9). The met line number indicates the whole line of met through which the maximum ordinate of the trajectory passes. This is a function of adjusted QE and charge. Table A for the appropriate charge is entered with the adjusted QE and the line number is extracted.

FT 155-AM-1  
PROJ, ME, M107  
FUZE, PD, M557

TABLE A  
LINE NUMBER

CHARGE  
4G

LINE NUMBERS OF METEOROLOGICAL MESSAGE

| QUADRANT<br>ELEVATION<br>MILS | LINE<br>NUMBER |
|-------------------------------|----------------|
| 0.0- 144.6                    | 0              |
| 144.7- 276.7                  | 1              |
| 276.8- 416.3                  | 2              |
| 416.4- 554.6                  | 3              |
| 554.7- 677.1                  | 4              |
| 677.2- 851.7                  | 5              |
| 851.8-1100.9                  | 6              |
| 1101.0-1295.0                 | 7              |

NOTE - WHEN THE PROJECTILE MUST HIT THE TARGET ON THE ASCENDING BRANCH OF ITS TRAJECTORY, USE HEIGHT OF TARGET IN METERS TO ENTER THE TABLE ON PAGE XXV TO DETERMINE LINE NUMBER.

| MET DATA CORRECTION SHEET                                     |              |                            |                          |                        |             |              |               |             |   |
|---------------------------------------------------------------|--------------|----------------------------|--------------------------|------------------------|-------------|--------------|---------------|-------------|---|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                            |                          |                        |             |              |               |             |   |
| BATTERY DATA                                                  |              |                            |                          |                        | MET MESSAGE |              |               |             |   |
| CHARGE                                                        | ADJ QE       | CHART RG                   | LATITUDE                 | TYPE MESSAGE           | OCTANT      | AREA/UNIT    |               |             |   |
| 246                                                           | 316          | 3030                       | 30°N                     |                        |             |              |               |             |   |
| ALT OF BTRY (10m)                                             |              |                            |                          | DATE                   | TIME        | ALT MDP      | PRESSURE      |             |   |
| 340                                                           |              |                            |                          |                        |             |              |               |             |   |
| ALT OF MDP                                                    |              |                            |                          | LINE NO                | WIND DIR    | WIND SPEED   | AIR TEMP      | AIR DENSITY |   |
|                                                               |              |                            |                          | 62                     | 5900        | 17           | 100.8         | 93.8        |   |
| BTRY ABOVE MDP (Δh)                                           |              |                            |                          | ΔR CORRECTION          |             |              | ±             |             |   |
| 389                                                           |              |                            |                          |                        |             |              |               |             |   |
| ALT OF TARGET (nearest meter)                                 |              |                            |                          | CORRECTED VALUES       |             |              |               |             |   |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                            |                          |                        |             |              |               |             |   |
| ALT OF BURST                                                  |              |                            |                          |                        |             |              |               |             |   |
| ALT OF BTRY (nearest meter)                                   |              |                            |                          |                        |             |              |               |             |   |
| 336                                                           |              |                            |                          |                        |             |              |               |             |   |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              |                            |                          | COMP RG                | CHART RG    | ENTRY RG     |               |             |   |
|                                                               |              |                            |                          |                        | 5030        |              |               |             |   |
| WIND COMPONENTS AND DEFLECTION                                |              |                            |                          |                        |             |              |               |             |   |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              |                            |                          | 6400                   |             |              |               |             |   |
| DIRECTION OF WIND                                             |              |                            |                          |                        |             |              |               |             |   |
| (651)                                                         |              |                            |                          |                        |             |              |               |             |   |
| DIRECTION OF FIRE                                             |              |                            |                          | 700                    |             |              |               |             |   |
| CHART DIRECTION OF WIND                                       |              |                            |                          |                        |             |              |               |             |   |
| CROSS WIND                                                    | WIND SPEED   | x COMP L                   | = L                      | KNOTS                  | x UNIT CORR | CROSS WIND L | DRIFT CORR    | L           | R |
| RANGE WIND                                                    | WIND SPEED   | x COMP H                   | = H                      | KNOTS                  | x UNIT CORR | RANGE WIND R | MET DEFL CORR | L           | R |
| MET RANGE CORRECTION                                          |              |                            |                          |                        |             |              |               |             |   |
|                                                               | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS       | PLUS        | MINUS        |               |             |   |
| RANGE WIND                                                    |              | 0                          |                          |                        |             |              |               |             |   |
| AIR TEMP                                                      |              | 100%                       |                          |                        |             |              |               |             |   |
| AIR DENSITY                                                   |              | 100%                       |                          |                        |             |              |               |             |   |
| PROJ WEIGHT                                                   | 30           |                            |                          |                        |             |              |               |             |   |
| ROTATION                                                      |              |                            |                          |                        |             |              |               |             |   |
| MET RANGE CORR                                                |              |                            |                          |                        |             |              |               |             |   |
| COMPUTATION OF VE                                             |              |                            |                          |                        |             |              |               |             |   |
| PROP TEMP                                                     | +82 °F       | VE                         | M/S                      | TOTAL RANGE CORRECTION |             |              |               |             |   |
|                                                               |              | CHANGE TO MV FOR PROP TEMP | M/S                      | MET RANGE CORRECTION   |             |              |               |             |   |
|                                                               |              |                            | M/S                      | MV UNIT CORRECTION     |             |              |               |             |   |
| OLD VE                                                        |              | MET FUZE                   | M/S                      | FUZE CORRECTION        |             |              |               |             |   |
|                                                               |              | + NEW FZ CORR              | M/S                      | TOTAL FUZE CORRECTION  |             |              |               |             |   |
| TARGET NO.                                                    |              | BATTERY                    |                          | DATE/TIME              |             |              |               |             |   |

DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
\* U.S. G.P.O. 1977-765037/45

Figure 6-9. Entry of met line number.

*e. Enter met message data (fig 6-10).* The data from the identification line and the line determined above are recorded in the Met Message Block. MDP

altitude, wind direction, and windspeed values are recorded in the other blocks as indicated.

| BATTERY DATA                                     |              |                 |                          |                  |          |                       |                 |             |                   | MET MESSAGE |  |  |  |
|--------------------------------------------------|--------------|-----------------|--------------------------|------------------|----------|-----------------------|-----------------|-------------|-------------------|-------------|--|--|--|
| CHARGE                                           | ADJ OF       | CHART RG        | SATITUDE                 | TYPE MESSAGE     | OCTANT   | AREA/UNIT             |                 |             |                   |             |  |  |  |
| 400                                              | 3/4          | 3030            | 304N                     | 111-03           | 1        | 347 985               |                 |             |                   |             |  |  |  |
| ALT OF BTRY (10m)                                |              |                 |                          | DATA             | TIME     | ALT MOD               | PRESSURE        |             |                   |             |  |  |  |
| 340                                              |              |                 |                          | 27               | 1230     | 530                   | 972             |             |                   |             |  |  |  |
| ALT OF MDP                                       |              |                 |                          | LINE NO          | WIND DIR | WIND SPEED            | AIR TEMP        | AIR DENSITY |                   |             |  |  |  |
|                                                  |              |                 |                          | 02               | 5700     | 17                    | 100.8           | 93.8        |                   |             |  |  |  |
| BTRY ABOVE MDP (Ah)                              |              |                 |                          | Ah CORRECTION    |          |                       |                 |             |                   |             |  |  |  |
| BELOW                                            |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| ALT OF TARGET (nearest meter)                    |              |                 |                          | CORRECTED VALUES |          |                       |                 |             |                   |             |  |  |  |
| 389                                              |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| HEIGHT OF BURST ABOVE TARGET                     |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| ALT OF BURST                                     |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| ALT OF BTRY (nearest meter)                      |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| 336                                              |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)           |              |                 |                          | COMP RG          |          | CHART RG              |                 | ENTRY RG    |                   |             |  |  |  |
|                                                  |              |                 |                          |                  |          | 5030                  |                 |             |                   |             |  |  |  |
| WIND COMPONENTS AND DEFLECTION                   |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD |              |                 |                          | 6400             |          |                       |                 |             |                   |             |  |  |  |
| DIRECTION OF WIND                                |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| (651)                                            |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| DIRECTION OF FIRE                                |              |                 |                          | 700              |          |                       |                 |             |                   |             |  |  |  |
| CHART DIRECTION OF FIRE                          |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| CROSS WIND                                       |              | WIND SPEED      | * COMP R                 | = R              | KNOTS *  |                       | UNIT CORR       |             | CROSS WIND L CORR |             |  |  |  |
| WIND                                             |              | WIND SPEED      | * COMP H                 | = TAIL HEAD      | KNOTS    |                       | MET DEFL L CORR |             | R                 |             |  |  |  |
| MET RANGE CORRECTION                             |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
|                                                  | KNOWN VALUES | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS     | MINUS                 |                 |             |                   |             |  |  |  |
| RANGE WIND                                       | H            | 0               | H                        |                  |          |                       |                 |             |                   |             |  |  |  |
| AIR TEMP                                         |              | 100%            | D                        |                  |          |                       |                 |             |                   |             |  |  |  |
| AIR DENSITY                                      |              | 100%            | D                        |                  |          |                       |                 |             |                   |             |  |  |  |
| PROJ HEIGHT                                      |              |                 | D                        |                  |          |                       |                 |             |                   |             |  |  |  |
| ROTATION                                         |              |                 | I                        |                  |          |                       |                 |             |                   |             |  |  |  |
|                                                  |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
|                                                  |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
|                                                  |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
|                                                  |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
|                                                  |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| COMPUTATION OF VE                                |              |                 |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| PROP TEMP                                        | +82          | M/S             |                          | TOTAL CORRECTION |          | TOTAL FUZE CORRECTION |                 |             |                   |             |  |  |  |
|                                                  |              | MET FUZE        |                          |                  |          |                       |                 |             |                   |             |  |  |  |
| +NEW FZ CORR                                     |              |                 |                          | +2-AVG FZ CORR   |          |                       |                 |             |                   |             |  |  |  |
| NET NO.                                          |              | BATTERY         |                          | DATE TIME        |          |                       |                 |             |                   |             |  |  |  |

DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
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| BALLISTIC MET MESSAGE                                                                             |                |                              |                                                                                                                                                                                                                                                                  |                               |                                                            |                       |                                |                                |
|---------------------------------------------------------------------------------------------------|----------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|------------------------------------------------------------|-----------------------|--------------------------------|--------------------------------|
| For use of this form, see FM 8-15; the proponent agency is United States Continental Army Command |                |                              |                                                                                                                                                                                                                                                                  |                               |                                                            |                       |                                |                                |
| IDENTIFICATION                                                                                    | TYPE MSG       | OCTANT                       | LOCATION<br><small> <math>\begin{matrix} 1 &amp; 2 &amp; 3 \\ \text{---} &amp; \text{---} &amp; \text{---} \end{matrix}</math> <br/> or<br/> <math>\begin{matrix} 1 &amp; 2 &amp; 3 \\ \text{---} &amp; \text{---} &amp; \text{---} \end{matrix}</math> </small> | DATE<br>YY                    | TIME (GMT)<br>G <sub>0</sub> G <sub>1</sub> G <sub>2</sub> | DURATION (HOURS)<br>G | STATION HEIGHT (10's M)<br>hhh | MDP PRESSURE (% OF STD)<br>PPP |
| METB                                                                                              | K              | Q                            |                                                                                                                                                                                                                                                                  |                               |                                                            |                       |                                |                                |
| METB                                                                                              | 3              | 1                            | 347985                                                                                                                                                                                                                                                           | 27                            | 125                                                        | 0                     | 055                            | 972                            |
|                                                                                                   |                |                              | BALLISTIC WINDS                                                                                                                                                                                                                                                  |                               |                                                            | BALLISTIC AIR         |                                |                                |
| ZONE HEIGHT (METERS)                                                                              | LINE NUMBER ZZ | DIRECTION (100's MILS)<br>dd | SPEED (KNOTS)<br>FF                                                                                                                                                                                                                                              | TEMPERATURE (% OF STD)<br>TTT | DENSITY (% OF STD)<br>AAA                                  |                       |                                |                                |
| SURFACE                                                                                           | 00             | 58                           | 16                                                                                                                                                                                                                                                               | 010                           | 958                                                        |                       |                                |                                |
| 200                                                                                               | 01             | 58                           | 16                                                                                                                                                                                                                                                               | 010                           | 960                                                        |                       |                                |                                |
| 500                                                                                               | 02             | 59                           | 17                                                                                                                                                                                                                                                               | 008                           | 958                                                        |                       |                                |                                |
| 1000                                                                                              | 03             | 60                           | 21                                                                                                                                                                                                                                                               | 004                           | 960                                                        |                       |                                |                                |
| 1500                                                                                              | 04             |                              |                                                                                                                                                                                                                                                                  |                               |                                                            |                       |                                |                                |

**Figure 6-10. Entry of met message data.**



f. Compute  $\Delta h$ , height of target above gun, chart direction of wind (fig 6-11).

(1) The difference in altitude between the battery and the MDP must be determined in order to correct the values for temperature and density.

(2) Height of target above gun (VI)

is determined to the nearest meter, then expressed to the nearest 100 meters. It will be used to determine complementary range.

(3) Chart direction of the wind is used to divide the wind direction into crosswind and rangewind components.

| MET DATA CORRECTION SHEET                                     |                            |                    |                             |                       |                  |                |          |                   |  |
|---------------------------------------------------------------|----------------------------|--------------------|-----------------------------|-----------------------|------------------|----------------|----------|-------------------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                            |                    |                             |                       |                  |                |          |                   |  |
| BATTERY DATA                                                  |                            |                    |                             |                       | MET MESSAGE      |                |          |                   |  |
| CHARGE                                                        | ADJ DE                     | CHART RG           | LATITUDE                    | TYPE MESSAGE          | OCTANT           | AREA/JUNY      |          |                   |  |
| 468                                                           | 316                        | 3030               | 30°N                        | MET B 3               | 1                | 347 985        |          |                   |  |
| ALT OF BTRY (10m)                                             |                            | 340                |                             | DATE                  | TIME             | ALT MDP        |          | PRESSURE          |  |
|                                                               |                            | 550                |                             | 27                    | 1230             | 350            |          | 972               |  |
| ALT OF MDP                                                    |                            | 550                |                             | LINE NO               | WIND DIR         | WIND SPEED     | AIR TEMP | AIR DENSITY       |  |
|                                                               |                            | -210               |                             | 82                    | 5900             | 17             | 100.8    | 95.8              |  |
| BTRY ABOVE MDP ( $\Delta h$ )                                 |                            | -210               |                             | $\Delta h$ CORRECTION |                  |                |          |                   |  |
| ALT OF TARGET (nearest meter)                                 |                            | 389                |                             | CORRECTED VALUES      |                  |                |          |                   |  |
| HEIGHT OF BURST ABOVE TARGET                                  |                            | —                  |                             |                       |                  |                |          |                   |  |
| ALT OF BURST                                                  |                            | 389                |                             |                       |                  |                |          |                   |  |
| ALT OF BTRY (nearest meter)                                   |                            | 336                |                             |                       |                  |                |          |                   |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |                            | +53 $\approx$ +100 |                             | COMP RG               | CHART RG         | ENTRY RG       |          |                   |  |
|                                                               |                            |                    |                             |                       | 5030             |                |          |                   |  |
| WIND COMPONENTS AND DEFLECTION                                |                            |                    |                             |                       |                  |                |          |                   |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |                            | 6400               |                             |                       |                  |                |          |                   |  |
| DIRECTION OF WIND                                             |                            | 5900               |                             |                       |                  |                |          |                   |  |
| (651)                                                         |                            |                    |                             |                       |                  |                |          |                   |  |
| DIRECTION OF FIRE                                             |                            | 700                |                             |                       |                  |                |          |                   |  |
| CHART DIRECTION OF WIND                                       |                            | 5200               |                             |                       |                  |                |          |                   |  |
| CROSS WIND                                                    |                            | WIND SPEED         |                             | KNOTS $\times$        |                  | UNIT CORR      |          | CROSS WIND L CORR |  |
| RANGE WIND                                                    |                            | WIND SPEED         |                             | KNOTS                 |                  | TAIL HEAD      |          | MET DEFL CORR     |  |
|                                                               |                            | $\times$ COMP R    |                             | $\times$ COMP H       |                  |                |          |                   |  |
| MET RANGE CORRECTION                                          |                            |                    |                             |                       |                  |                |          |                   |  |
|                                                               | KNOWN VALUES               | STANDARD VALUES    | VARIATIONS FROM STANDARD    | UNIT CORRECTIONS      | PLUS             | MINUS          |          |                   |  |
| RANGE WIND                                                    | T                          | 0                  | T                           |                       |                  |                |          |                   |  |
| AIR TEMP                                                      | H                          | 100%               | H                           |                       |                  |                |          |                   |  |
| AIR DENSITY                                                   |                            | 100%               |                             |                       |                  |                |          |                   |  |
| PROJ WEIGHT                                                   |                            |                    |                             |                       |                  |                |          |                   |  |
| ROTATION                                                      |                            |                    |                             |                       |                  |                |          |                   |  |
|                                                               |                            |                    |                             |                       |                  | MET RANGE CORR |          |                   |  |
| COMPUTATION OF VE                                             |                            |                    |                             |                       |                  |                |          |                   |  |
| PROP TEMP                                                     | VE                         | M/S                | TOTAL RANGE CORRECTION      |                       |                  |                |          |                   |  |
| +82                                                           | CHANGE TO MV FOR PROP TEMP | M/S                | MET RANGE CORRECTION        |                       |                  |                |          |                   |  |
|                                                               |                            | M/S                | $\Delta V$ RANGE CORRECTION |                       |                  |                |          |                   |  |
| DENSITY                                                       |                            |                    | TOTAL FUZE CORRECTION       |                       |                  |                |          |                   |  |
| PROJ WEIGHT                                                   |                            |                    | MET FUZE CORRECTION         |                       |                  |                |          |                   |  |
|                                                               |                            |                    | FUZE CORRECTION             |                       |                  |                |          |                   |  |
|                                                               |                            |                    | TOTAL FUZE CORRECTION       |                       |                  |                |          |                   |  |
| MET FUZE CORR                                                 |                            |                    |                             |                       |                  |                |          |                   |  |
| OLD FZ CORR                                                   |                            |                    | + NEW FZ CORR               |                       | = +2-AVG FZ CORR |                |          |                   |  |
| TARGET NO                                                     |                            |                    | BATTERY                     |                       | DATE/TIME        |                |          |                   |  |

DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
\* U.S. G.P.O. 1977-765037/45

Figure 6-11. Computation of height of target above gun, chart direction of wind.

g. Enter tables.

(1) Table B. The complementary range is extracted from table B by entering with the chart range to the nearest listed value and the height of target above gun to the nearest 100. It is recorded as shown in figure 6-12.

CHARGE  
4GTABLE B  
COMPLEMENTARY RANGE  
LINE NUMBERFT 155-AM-1  
PROJ, HE, M107  
FUZE, PD, M557CHANGE IN RANGE, IN METERS,  
TO CORRECT FOR COMPLEMENTARY ANGLE OF SITE

LINE NUMBERS OF METEOROLOGICAL MESSAGE

| LINE NO. | RANGE METERS | HEIGHT OF TARGET ABOVE GUN - METERS |      |      |      |   |     |     |     |
|----------|--------------|-------------------------------------|------|------|------|---|-----|-----|-----|
|          |              | -400                                | -300 | -200 | -100 | 0 | 100 | 200 | 300 |
| 0        | 3500         | -63                                 | -48  | -33  | -17  | 0 | 17  | 35  | 54  |
|          | 3600         | -65                                 | -50  | -34  | -17  | 0 | 18  | 37  | 56  |
|          | 3700         | -67                                 | -51  | -35  | -18  | 0 | 19  | 38  | 58  |
|          | 3800         | -70                                 | -53  | -36  | -18  | 0 | 19  | 39  | 60  |
|          | 3900         | -72                                 | -55  | -37  | -19  | 0 | 20  | 40  | 61  |
|          | 4000         | -74                                 | -57  | -38  | -20  | 0 | 20  | 41  | 63  |
|          | 4100         | -76                                 | -58  | -40  | -20  | 0 | 21  | 43  | 65  |
|          | 4200         | -79                                 | -60  | -41  | -21  | 0 | 22  | 44  | 67  |
|          | 4300         | -81                                 | -62  | -42  | -21  | 0 | 22  | 45  | 69  |
|          | 4400         | -83                                 | -64  | -43  | -22  | 0 | 23  | 46  | 71  |
| 1        | 4500         | -86                                 | -65  | -44  | -23  | 0 | 23  | 48  | 73  |
|          | 4600         | -88                                 | -67  | -46  | -23  | 0 | 24  | 49  | 75  |
|          | 4700         | -90                                 | -69  | -47  | -24  | 0 | 25  | 50  | 77  |
|          | 4800         | -93                                 | -71  | -48  | -24  | 0 | 25  | 52  | 79  |
|          | 4900         | -95                                 | -73  | -49  | -25  | 0 | 26  | 53  | 81  |
|          | 5000         | -98                                 | -75  | -51  | -26  | 0 | 27  | 55  | 83  |
|          | 5100         | -101                                | -77  | -52  | -26  | 0 | 27  | 56  | 86  |

| MET DATA CORRECTION SHEET                                     |              |                          |                          |                  |             |                        |           |             |                   |
|---------------------------------------------------------------|--------------|--------------------------|--------------------------|------------------|-------------|------------------------|-----------|-------------|-------------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                          |                          |                  |             |                        |           |             |                   |
| BATTERY DATA                                                  |              |                          |                          |                  | MET MESSAGE |                        |           |             |                   |
| CHARGE                                                        | ADJ OF       | CHART RG                 | LATITUDE                 | TYPE MESSAGE     | OCTANT      | AREA/UNIT              |           |             |                   |
| 4G6                                                           | 3/6          | 3030                     | 30°N                     | MET B 3          | 1           | 347985                 |           |             |                   |
| ALT OF BTRY (10m)                                             |              | 340                      |                          | DATE             | TIME        | ALT MDP                | PRESSURE  |             |                   |
|                                                               |              |                          |                          | 27               | 1230        | 350                    | 972       |             |                   |
| ALT OF MDP                                                    |              | 550                      |                          | LINE NO          | WIND DIR    | WIND SPEED             | AIR TEMP  | AIR DENSITY |                   |
|                                                               |              |                          |                          | 02               | 5900        | 17                     | 100.8     | 95.8        |                   |
| BTRY ABOVE MDP (Δh)                                           |              | -210                     |                          | Δh CORRECTION    |             |                        |           |             |                   |
| ALT OF TARGET (nearest meter)                                 |              | 389                      |                          | CORRECTED VALUES |             |                        |           |             |                   |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                          |                          |                  |             |                        |           |             |                   |
| ALT OF BURST                                                  |              | 389                      |                          |                  |             |                        |           |             |                   |
| ALT OF BTRY (nearest meter)                                   |              | 336                      |                          |                  |             |                        |           |             |                   |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              | +53 ≈ +100               |                          | COMP RG          | +27         | CHART RG               | 5030      | ENTRY RG    |                   |
| WIND COMPONENTS AND DEFLECTION                                |              |                          |                          |                  |             |                        |           |             |                   |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400                     |                          |                  |             |                        |           |             |                   |
| DIRECTION OF WIND                                             |              | 5900                     |                          |                  |             |                        |           |             |                   |
| (651)                                                         |              |                          |                          |                  |             |                        |           |             |                   |
| DIRECTION OF FIRE                                             |              | 700                      |                          |                  |             |                        |           |             |                   |
| CHART DIRECTION OF WIND                                       |              | 5200                     |                          |                  |             |                        |           |             |                   |
| CROSS WIND                                                    | WIND SPEED   | L                        |                          | = L              |             | KNOTS                  | UNIT CORR |             | CROSS WIND L CORR |
| RANGE WIND                                                    | WIND SPEED   | T                        |                          | = T              |             | KNOTS                  | TAIL HEAD |             | MET DEFL CORR     |
| MET RANGE CORRECTION                                          |              |                          |                          |                  |             |                        |           |             |                   |
|                                                               | KNOWN VALUES | STANDARD VALUES          | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS        | MINUS                  |           |             |                   |
| RANGE WIND                                                    | T H          | 0                        | T H                      |                  |             |                        |           |             |                   |
| AIR TEMP                                                      |              | 100%                     | D I                      |                  |             |                        |           |             |                   |
| AIR DENSITY                                                   |              | 100%                     | D I                      |                  |             |                        |           |             |                   |
| PROJ WEIGHT                                                   | 3            |                          | D I                      |                  |             |                        |           |             |                   |
| ROTATION                                                      |              |                          | D I                      |                  |             |                        |           |             |                   |
| MET RANGE CORR                                                |              |                          |                          |                  |             |                        |           |             |                   |
| COMPUTATION OF VE                                             |              |                          |                          |                  |             |                        |           |             |                   |
| PROP TEMP                                                     | +82 °F       | VE                       | M/S                      |                  |             | TOTAL RANGE CORRECTION |           |             |                   |
|                                                               |              | CHANGE TO MV FOR °F TEMP | M/S                      |                  |             | MET RANGE CORRECTION   |           |             |                   |
|                                                               |              |                          | M/S                      |                  |             |                        |           |             |                   |

Figure 6-12. Determination of complementary range.

FT 155-AM-1  
PROJ. HE, M107  
FUZE. PD. M557

| CHART<br>DIRECTION<br>OF WIND | CROSS<br>WIND | RANGE<br>WIND | CHART<br>DIRECTION<br>OF WIND | CROSS<br>WIND | RANGE<br>WIND |
|-------------------------------|---------------|---------------|-------------------------------|---------------|---------------|
| MIL                           | KNOT          | KNOT          | MIL                           | KNOT          | KNOT          |
| 0                             | 0             | H1.00         | 3200                          | 0             | T1.00         |
| 100                           | R.10          | H.99          | 3300                          | L.10          | T.99          |
| 200                           | R.20          | H.98          | 3400                          | L.20          | T.98          |
| 300                           | R.29          | H.96          | 3500                          | L.29          | T.96          |
| 400                           | R.38          | H.92          | 3600                          | L.38          | T.92          |
| 500                           | R.47          | H.88          | 3700                          | L.47          | T.88          |
| 600                           | R.56          | H.83          | 3800                          | L.56          | T.83          |
| 700                           | R.63          | H.77          | 3900                          | L.63          | T.77          |
| 800                           | R.71          | H.71          | 4000                          | L.71          | T.71          |
| 900                           | R.77          | H.63          | 4100                          | L.77          | T.63          |
| 1000                          | R.83          | H.56          | 4200                          | L.83          | T.56          |
| 1100                          | R.88          | H.47          | 4300                          | L.88          | T.47          |
| 1200                          | R.92          | H.38          | 4400                          | L.92          | T.38          |
| 1300                          | R.96          | H.29          | 4500                          | L.96          | T.29          |
| 1400                          | R.98          | H.20          | 4600                          | L.98          | T.20          |
| 1500                          | R.99          | H.10          | 4700                          | L.99          | T.10          |
| 1600                          | R1.00         | 0             | 4800                          | L1.00         | 0             |
| 1700                          | R.99          | T.10          | 4900                          | L.99          | H.10          |
| 1800                          | R.98          | T.20          | 5000                          | L.98          | H.20          |
| 1900                          | R.96          | T.29          | 5100                          | L.96          | H.29          |
| 2000                          | R.92          | T.38          | 5200                          | L.92          | H.38          |
|                               |               | .47           | 5300                          | L.88          | H.47          |
|                               |               | .56           | 5400                          | L.83          | H.56          |
|                               |               | .63           | 5500                          | L.77          | H.63          |

**Figure 6-13. Determination of wind components.**

(3) *Table D.* This table lists the corrections that must be applied to temperature and density to compensate for the difference in altitude between the battery and the MDP. The table is entered with  $\Delta h$  and the values extracted. If  $\Delta h$  is minus, the values are plus. If  $\Delta h$  is plus, the values are minus. The values are recorded as shown in figure 6-14.

FT 155-AM-1

PROJ, HE, M107  
FUZE, PD, M557

TABLE D

TEMPERATURE AND DENSITY CORRECTIONS

CORRECTIONS TO TEMPERATURE (DT) AND DENSITY (DD), IN PERCENT TO COMPENSATE FOR THE DIFFERENCE IN ALTITUDE, IN METERS, BETWEEN THE BATTERY AND THE MDP

| DM       | 0     | +10-  | +20-  | +30-  | +40-  | +50-  | +60-  |
|----------|-------|-------|-------|-------|-------|-------|-------|
| 0 DT     | 0.0   | 0.0   | 0.0   | -0.1+ | -0.1+ | -0.1+ | -0.1+ |
| 0 DD     | 0.0   | -0.1+ | -0.2+ | -0.3+ | -0.4+ | -0.5+ | -0.6+ |
| +100- DT | -0.2+ | -0.2+ | -0.2+ | -0.3+ | -0.3+ | -0.3+ | -0.3+ |
| 100- DD  | -1.0+ | -1.1+ | -1.2+ | -1.3+ | -1.4+ | -1.5+ | -1.6+ |
| +200- DT | -0.5+ | -0.5+ | -0.5+ | -0.6+ | -0.6+ | -0.6+ | -0.6+ |
| 200- DD  | -2.0+ | -2.1+ | -2.2+ | -2.3+ | -2.4+ | -2.5+ | -2.6+ |
| +300- DT | -0.7+ | -0.7+ | -0.7+ | -0.8+ | -0.8+ | -0.8+ | -0.8+ |
| 300- DD  | -3.0+ | -3.1+ | -3.2+ | -3.3+ | -3.4+ | -3.5+ | -3.6+ |

- NOTES - 1. DM IS BATTERY HEIGHT ABOVE OR BELOW THE MDP.  
2. IF ABOVE THE MDP, USE THE SIGN BEFORE THE NUMBER.  
3. IF BELOW THE MDP, USE THE SIGN AFTER THE NUMBER.

| MET DATA CORRECTION SHEET                                     |              |                    |                          |                        |             |            |                   |             |  |
|---------------------------------------------------------------|--------------|--------------------|--------------------------|------------------------|-------------|------------|-------------------|-------------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                    |                          |                        |             |            |                   |             |  |
| BATTERY DATA                                                  |              |                    |                          |                        | MET MESSAGE |            |                   |             |  |
| CHARGE                                                        | ADJ DE       | CHART RG           | LATITUDE                 | TYPE MESSAGE           | OCTANT      | AREA/UNIT  |                   |             |  |
| 468                                                           | 316          | 5030               | 30°N                     | MET 8 3                | 1           | 347985     |                   |             |  |
| ALT OF BTRY (10m)                                             |              | 340                |                          | DATE                   | TIME        | ALT MDP    |                   | PRESSURE    |  |
|                                                               |              |                    |                          | 27                     | 1230        | 350        |                   | 872         |  |
| ALT OF MDP                                                    |              | 550                |                          | LINE NO                | WIND DIR    | WIND SPEED | AIR TEMP          | AIR DENSITY |  |
|                                                               |              |                    |                          | 02                     | 5900        | 17         | 100.8             | 95.8        |  |
| BTRY ABOVE MDP ( $\Delta h$ )                                 |              | -210               |                          | $\Delta h$ CORRECTION  |             | 0.5        |                   | 2.1         |  |
| ALT OF TARGET (nearest meter)                                 |              | 389                |                          | CORRECTED VALUES       |             |            |                   |             |  |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                    |                          |                        |             |            |                   |             |  |
| ALT OF BURST                                                  |              | 389                |                          |                        |             |            |                   |             |  |
| ALT OF BTRY (nearest meter)                                   |              | 336                |                          |                        |             |            |                   |             |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              | +53 $\approx$ +100 |                          | COMP RG                | +27         | CHART RG   | 5030              | ENTRY RG    |  |
| WIND COMPONENTS AND DEFLECTION                                |              |                    |                          |                        |             |            |                   |             |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400               |                          |                        |             |            |                   |             |  |
| DIRECTION OF WIND                                             |              | 5900               |                          |                        |             |            |                   |             |  |
| (650)                                                         |              |                    |                          |                        |             |            |                   |             |  |
| DIRECTION OF FIRE                                             |              | 700                |                          |                        |             |            |                   |             |  |
| CHART DIRECTION OF WIND                                       |              | 5200               |                          |                        |             |            |                   |             |  |
| CROSS WIND                                                    | WIND SPEED   | 0.92               |                          | = L                    | KNOTS       | UNIT CORR  | ROTATION CORR L R |             |  |
| RANGE WIND                                                    | WIND SPEED   | 0.38               |                          | = R                    | KNOTS       | TAIL HEAD  | CROSS WIND L R    |             |  |
| MET RANGE CORRECTION                                          |              |                    |                          |                        |             |            |                   |             |  |
|                                                               | KNOWN VALUES | STANDARD VALUES    | VARIATIONS FROM STANDARD | UNIT CORRECTIONS       | PLUS        | MINUS      |                   |             |  |
| RANGE WIND                                                    | T H          | 0                  | T H                      |                        |             |            |                   |             |  |
| AIR TEMP                                                      |              | 100%               | D I                      |                        |             |            |                   |             |  |
| AIR DENSITY                                                   |              | 100%               | D I                      |                        |             |            |                   |             |  |
| PROJ WEIGHT                                                   | 30           |                    | D I                      |                        |             |            |                   |             |  |
| ROTATION                                                      |              |                    |                          |                        |             |            |                   |             |  |
| MET RANGE CORR                                                |              |                    |                          |                        |             |            |                   |             |  |
| COMPUTATION OF VE                                             |              |                    |                          |                        |             |            |                   |             |  |
| PROP. I TEMP                                                  | +82          | VE                 | M/S                      | TOTAL RANGE CORRECTION |             |            |                   |             |  |
|                                                               | CHANGE TO MV |                    |                          | MET RANGE CORRECTION   |             |            |                   |             |  |
|                                                               | PROP TEMP    |                    |                          | A V RANGE CORRECTION   |             |            |                   |             |  |
| + NEW FZ CORR = +2 AVG FZ CORR                                |              |                    |                          |                        |             |            |                   |             |  |
| BATTERY                                                       |              | DATE/TIME          |                          |                        |             |            |                   |             |  |

DA FORM 74200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

\*U.S. G.P.O. 1977-765037/45

Figure 6-14. Temperature and density corrections.

(4) *Table E.* Standard propellant temperature is +70° F. An increase in propellant temperature will increase muzzle velocity; a decrease will decrease muzzle velocity. Table E lists the effects on muzzle velocity of propellant temperature. The table is entered with the propellant temperature to the nearest degree Fahrenheit and the change to muzzle velocity (MV) is interpolated. The value is recorded as shown in figure 6-15.

*Note.* Interpolation is not necessary if all values have been interpolated previously and a supplemental table E constructed listing muzzle velocity changes for all temperatures.

TABLE E  
PROPELLANT TEMPERATURE

EFFECTS ON MUZZLE VELOCITY DUE TO PROPELLANT TEMPERATURE

| TEMPERATURE OF PROPELLANT DEGREES F | EFFECT ON VELOCITY M/S | TEMPERATURE OF PROPELLANT DEGREES C |
|-------------------------------------|------------------------|-------------------------------------|
| -40                                 | -6.3                   | -40.0                               |
| -30                                 | -5.7                   | -34.4                               |
| -20                                 | -5.2                   | -28.9                               |
| -10                                 | -4.6                   | -23.3                               |
| 0                                   | -4.0                   | -17.8                               |
| 10                                  | -3.4                   | -12.2                               |
| 20                                  | -2.9                   | -6.7                                |
| 30                                  | -2.3                   | -1.1                                |
| 40                                  | -1.7                   | 4.4                                 |
| 50                                  | -1.1                   | 10.0                                |
| 60                                  | -0.6                   | 15.6                                |
| 70                                  | 0.0                    | 21.1                                |
| 80                                  | 0.6                    | 26.7                                |
| 90                                  | 1.1                    | 32.2                                |
| 100                                 | 1.7                    | 37.8                                |
| 110                                 | 2.3                    | 43.3                                |
| 120                                 | 2.9                    | 48.9                                |
| 130                                 | 3.4                    | 54.4                                |

**MET DATA CORRECTION SHEET**  
For use of this form, see FM 6-40; proponent agency is TRADOC

| BATTERY DATA                                     |              |                            |                          | MET MESSAGE            |            |           |             |
|--------------------------------------------------|--------------|----------------------------|--------------------------|------------------------|------------|-----------|-------------|
| CHARGE                                           | ADJ OF       | CHART RG                   | LATITUDE                 | TYPE MESSAGE           | OCTANT     | AREA/UNIT |             |
| 4GB                                              | 3/6          | 5030                       | 30°N                     | METB 3                 | 1          | 347985    |             |
| ALT OF BTRY (10m)                                |              | 340                        | DATE                     | TIME                   | ALL WDS    | PRESSURE  |             |
|                                                  |              |                            | 27                       | 1230                   | 530        | 97.2      |             |
| ALT OF MDP                                       |              | 550                        | LINE NO.                 | WIND DIR               | WIND SPEED | AIR TEMP  | AIR DENSITY |
|                                                  |              |                            | 02                       | 5900                   | 17         | 100.8     | 95.8        |
| BTRY ABOVE MDP (AN)                              |              | -210                       | AN CORRECTION            |                        |            | 0.5       | 2.1         |
| ALT OF TARGET (nearest meter)                    |              | 389                        | CORRECTED VALUES         |                        |            |           |             |
| HEIGHT OF BURST ABOVE TARGET                     |              |                            |                          |                        |            |           |             |
| ALT OF BURST                                     |              | 389                        |                          |                        |            |           |             |
| ALT OF BTRY (nearest meter)                      |              | 336                        |                          |                        |            |           |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)           |              | +53 ≈ +100                 | COMP RG                  | +27                    | CHART RG   | 5030      | ENTRY RG    |
| <b>WIND COMPONENTS AND DEFLECTION</b>            |              |                            |                          |                        |            |           |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD |              | 8400                       |                          |                        |            |           |             |
| DIRECTION OF WIND                                |              | 5900                       |                          |                        |            |           |             |
| (651)                                            |              |                            |                          |                        |            |           |             |
| DIRECTION OF FIRE                                |              | 700                        |                          |                        |            |           |             |
| CHART DIRECTION OF WIND                          |              | 5200                       |                          |                        |            |           |             |
| CROSS WIND SPEED                                 |              | 0.92                       | KNOTS                    | UNIT CORR              |            |           |             |
| RANGE WIND SPEED                                 |              | 0.38                       | KNOTS                    | TAIL                   |            |           |             |
| <b>MET RANGE CORRECTION</b>                      |              |                            |                          |                        |            |           |             |
| RANGE WIND                                       | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS       | PLUS       | MINUS     |             |
| AIR TEMP                                         |              | 100%                       |                          |                        |            |           |             |
| AIR DENSITY                                      |              | 100%                       |                          |                        |            |           |             |
| PROJ WEIGHT                                      | 30           |                            |                          |                        |            |           |             |
| ROTATION                                         |              |                            |                          |                        |            |           |             |
| <b>COMPUTATION OF VE</b>                         |              |                            |                          |                        |            |           |             |
| PROP TEMP                                        | +82 °F       | VE                         | M/S                      | TOTAL RANGE CORRECTION |            |           |             |
|                                                  |              | CHANGE TO MV FOR PROP TEMP | +0.7                     | MET RANGE CORRECTION   |            |           |             |
|                                                  |              | AV                         | M/S                      | AVG FZ CORR            |            |           |             |
| <b>OLD FZ CORR</b>                               |              |                            |                          |                        |            |           |             |
| <b>NEW FZ CORR</b>                               |              |                            |                          |                        |            |           |             |
| <b>DATE/TIME</b>                                 |              |                            |                          |                        |            |           |             |

SUPPLEMENT TO TABLE E  
TFT 155-AM-1  
CHARGE 4GB

|     | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    |
|-----|------|------|------|------|------|------|------|------|------|------|
| -40 | -6.3 |      |      |      |      |      |      |      |      |      |
| -30 | -5.7 | -5.8 | -5.8 | -5.9 | -6.0 | -6.1 | -6.1 | -6.2 | -6.2 |      |
| -20 | -5.2 | -5.3 | -5.3 | -5.3 | -5.4 | -5.5 | -5.5 | -5.6 | -5.6 | -5.7 |
| -10 | -4.6 | -4.7 | -4.7 | -4.8 | -4.8 | -4.9 | -5.0 | -5.0 | -5.1 | -5.1 |
| 0   | -4.0 | -4.1 | -4.1 | -4.2 | -4.2 | -4.3 | -4.4 | -4.4 | -4.5 | -4.5 |
| 10  | -3.4 | -3.4 | -3.3 | -3.2 | -3.2 | -3.2 | -3.1 | -3.0 | -3.0 | -3.0 |
| 20  | -2.9 | -2.8 | -2.8 | -2.7 | -2.7 | -2.6 | -2.5 | -2.5 | -2.4 | -2.4 |
| 30  | -2.3 | -2.2 | -2.2 | -2.1 | -2.1 | -2.0 | -1.9 | -1.9 | -1.8 | -1.8 |
| 40  | -1.7 | -1.6 | -1.6 | -1.5 | -1.5 | -1.4 | -1.3 | -1.3 | -1.2 | -1.2 |
| 50  | -1.1 | -1.1 | -1.0 | -0.9 | -0.9 | -0.8 | -0.8 | -0.7 | -0.7 | -0.7 |
| 60  | -0.6 | -0.5 | -0.5 | -0.4 | -0.4 | -0.3 | -0.2 | -0.2 | -0.1 | -0.1 |
| 70  | 0.0  | 0.1  | 0.1  | 0.2  | 0.2  | 0.3  | 0.4  | 0.4  | 0.5  | 0.5  |
| 80  | 0.6  | 0.6  | 0.7  | 0.8  | 0.8  | 0.8  | 0.9  | 1.0  | 1.0  | 1.0  |
| 90  | 1.1  | 1.2  | 1.2  | 1.3  | 1.3  | 1.4  | 1.5  | 1.5  | 1.6  | 1.6  |
| 100 | 1.7  | 1.8  | 1.8  | 1.9  | 1.9  | 2.0  | 2.1  | 2.1  | 2.2  | 2.2  |
| 110 | 2.3  | 2.4  | 2.4  | 2.5  | 2.5  | 2.6  | 2.7  | 2.7  | 2.8  | 2.8  |
| 120 | 2.9  | 2.9  | 3.0  | 3.1  | 3.1  | 3.1  | 3.2  | 3.3  | 3.3  | 3.3  |
| 130 | 3.4  |      |      |      |      |      |      |      |      |      |

DA FORM 7, 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

Figure 6-15. Correction for propellant temperature.

## h. Compute (fig 6-16):

(1) *Corrected values for temperature and density.* The values extracted from table D are applied to the met message temperature and density to determine the corrected values.

(2) *Entry range.* Entry range is determined by adding the comp range from table B to the chart range. The result is expressed to the nearest 100 meters.

(3) *Crosswind and rangewind.* The

windspeed from the met message is multiplied by the crosswind and rangewind components extracted from table C to determine the crosswind and rangewind values. These values are expressed to the nearest knot.

(4) *Variations from standard.* The values for rangewind, air temperature, air density, and projectile weight are entered in the Met Range Correction blocks and are compared to the standard values listed to determine the variation from standard.

| MET DATA CORRECTION SHEET                                     |              |                            |                          |                  |                        |            |           |                 |      |
|---------------------------------------------------------------|--------------|----------------------------|--------------------------|------------------|------------------------|------------|-----------|-----------------|------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                            |                          |                  |                        |            |           |                 |      |
| BATTERY DATA                                                  |              |                            |                          |                  | MET MESSAGE            |            |           |                 |      |
| CHARGE                                                        | ADJ OF       | CHART RC                   | LATITUDE                 | TYPE MESSAGE     | OCTANT                 | AREA/UNIT  |           |                 |      |
| 468316                                                        |              | 5030                       | 30°N                     | ME163            | 1                      | 347985     |           |                 |      |
| ALT OF BTRY (10m)                                             |              | 340                        |                          | DATE             | TIME                   | ALT MDP    | PRESSURE  |                 |      |
|                                                               |              |                            |                          | 27               | 1230                   | 530        | 872       |                 |      |
| ALT OF MDP                                                    |              | 550                        |                          | LINE NO          | WIND DIR               | WIND SPEED | AIR TEMP  | AIR DENSITY     |      |
|                                                               |              |                            |                          | 02               | 3900                   | 17         | 100.8     | 95.8            |      |
| BTRY ABOVE MDP (Ah)                                           |              | -210                       |                          | Ah CORRECTION    |                        | 0.50 2.1   |           |                 |      |
| ALT OF TARGET (nearest meter)                                 |              | 389                        |                          | CORRECTED VALUES |                        | 101.3 97.9 |           |                 |      |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                            |                          |                  |                        |            |           |                 |      |
| ALT OF BURST                                                  |              | 389                        |                          |                  |                        |            |           |                 |      |
| ALT OF BTRY (nearest meter)                                   |              | 336                        |                          |                  |                        |            |           |                 |      |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              | +53                        | +100                     | COMP RC          | +27                    | CHART RC   | 5030      | ENTRY RC        | 5057 |
| WIND COMPONENTS AND DEFLECTION                                |              |                            |                          |                  |                        |            |           |                 |      |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400                       |                          |                  |                        |            |           |                 |      |
| DIRECTION OF WIND                                             |              | 5900                       |                          |                  |                        |            |           |                 |      |
| (651)                                                         |              |                            |                          |                  |                        |            |           |                 |      |
| DIRECTION OF FIRE                                             |              | 700                        |                          |                  |                        |            |           |                 |      |
| CHART DIRECTION OF WIND                                       |              | 5200                       |                          |                  |                        |            |           |                 |      |
| CROSS WIND                                                    | WIND SPEED   | 17                         | * COMP                   | 0.92             | 16                     | KNOTS      | UNIT CORR | CROSS WIND CORR | L    |
| RANGE WIND                                                    | WIND SPEED   | 17                         | * COM                    | 0.38             | 6                      | KNOTS      | UNIT CORR | R               | L    |
| MET RANGE CORRECTION                                          |              |                            |                          |                  |                        |            |           |                 |      |
|                                                               | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                   | MINUS      |           |                 |      |
| RANGE WIND                                                    | 6            | 0                          | 6                        |                  |                        |            |           |                 |      |
| AIR TEMP                                                      | 101.3        | 100%                       | 1.3                      |                  |                        |            |           |                 |      |
| AIR DENSITY                                                   | 97.9         | 100%                       | 2.1                      |                  |                        |            |           |                 |      |
| PROJ WEIGHT                                                   | 3            | 4                          | 1                        |                  |                        |            |           |                 |      |
| ROTATION                                                      |              |                            |                          |                  |                        |            |           |                 |      |
| MET RANGE CORR                                                |              |                            |                          |                  |                        |            |           |                 |      |
| COMPUTATION OF VE                                             |              |                            |                          |                  |                        |            |           |                 |      |
| PROP TEMP                                                     | +82          | VE                         |                          | M/S              | TOTAL RANGE CORRECTION |            |           |                 |      |
|                                                               |              | CHANGE TO MV FOR PROP TEMP | +0.7                     | M/S              | MET RANGE CORRECTION   |            |           |                 |      |
|                                                               |              | ΔV                         |                          | M/S              | ΔV RANGE CORRECTION    |            |           |                 |      |
| OLD VE                                                        |              |                            |                          |                  |                        |            |           |                 |      |
|                                                               |              |                            | +2 = AVG VE              |                  |                        |            |           |                 |      |
|                                                               |              |                            |                          |                  |                        |            |           |                 |      |

Figure 6-16. Determination of corrected values.

## i. Enter tables.

(1) Table F. Columns 8-19 list unit corrections for drift, crosswind, muzzle velocity, rangewind, air density, air temperature, and projectile weight. Table F is entered with the entry range. Azimuth corrections for drift and crosswind are extracted from columns 8 and 9 and recorded. (See figure 6-17.) The values in columns 10 and 11 are both extracted and recorded because it is unknown at this time whether muzzle velocity variation will be an increase or decrease. The other values are extracted and recorded.

| PT 155-AR-1                      |  |      |  | PT 155-AR-1                      |    |                         |    | TABLE F<br>CORRECTION FACTORS |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    | CHARGE<br>4G |  |
|----------------------------------|--|------|--|----------------------------------|----|-------------------------|----|-------------------------------|----|-------------------------|----|-----|----|-----|-----------------------|--|--|--|--|--|------------------------------------|--------------|--|
| PROJ, ME, R107<br>FUZE, PD, R557 |  |      |  | PROJ, ME, R107<br>FUZE, PD, R557 |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| B                                |  | C    |  | 1                                | 10 | 11                      | 12 | 13                            | 14 | 15                      | 16 | 17  | 18 | 19  | RANGE CORRECTIONS FOR |  |  |  |  |  | PROJ WT<br>OF 1Q STQ<br>(4.5Q 15Q) |              |  |
| AZIMUTH<br>CORRECTIONS           |  |      |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| DRIFT<br>(CORR<br>TO L)          |  |      |  | MUZZLE<br>VELOCITY<br>1 R/S      |    | RANGE<br>WIND<br>1 KNOT |    | AIR<br>TEMP<br>1 PCT          |    | AIR<br>DENSITY<br>1 PCT |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
|                                  |  |      |  | DEC                              |    | INC                     |    | DEC                           |    | INC                     |    | DEC |    | INC |                       |  |  |  |  |  |                                    |              |  |
| MIL                              |  |      |  | MIL                              |    | MIL                     |    | MIL                           |    | MIL                     |    | MIL |    | MIL |                       |  |  |  |  |  |                                    |              |  |
| 3.9                              |  | 0.11 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.0                              |  | 0.12 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.1                              |  | 0.12 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.2                              |  | 0.12 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.3                              |  | 0.13 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.4                              |  | 0.13 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.5                              |  | 0.13 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.6                              |  | 0.13 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.7                              |  | 0.14 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.8                              |  | 0.14 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 4.9                              |  | 0.14 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.0                              |  | 0.14 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.1                              |  | 0.15 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.2                              |  | 0.15 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.3                              |  | 0.15 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.4                              |  | 0.15 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.5                              |  | 0.16 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.6                              |  | 0.16 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.7                              |  | 0.16 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.8                              |  | 0.16 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 5.9                              |  | 0.16 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.0                              |  | 0.16 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.1                              |  | 0.17 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.2                              |  | 0.17 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.3                              |  | 0.17 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.4                              |  | 0.17 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.5                              |  | 0.17 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.6                              |  | 0.18 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.7                              |  | 0.18 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.8                              |  | 0.18 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 6.9                              |  | 0.18 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 7.0                              |  | 0.19 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |
| 7.1                              |  | 0.19 |  |                                  |    |                         |    |                               |    |                         |    |     |    |     |                       |  |  |  |  |  |                                    |              |  |

| MET DATA CORRECTION SHEET                                     |              |                            |                          |                    |                        |                      |             |               |     |
|---------------------------------------------------------------|--------------|----------------------------|--------------------------|--------------------|------------------------|----------------------|-------------|---------------|-----|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                            |                          |                    |                        |                      |             |               |     |
| BATTERY DATA                                                  |              |                            |                          |                    | MET MESSAGE            |                      |             |               |     |
| CHARGE                                                        | ADJ Q        | CHART RG                   | LATITUDE                 | TYPE MESSAGE       | OCTANT                 | AREA/UNIT            |             |               |     |
| 166                                                           | 3/6          | 5030                       | 30°N                     | ME78 3             | 1                      | 347985               |             |               |     |
| ALT OF BTRY (10m)                                             | 340          |                            | DATE                     | TIME               | ALT MDP                | PRESSURE             |             |               |     |
| ALT OF MDP                                                    | 550          |                            | 02                       | 1230               | 330                    | 97.2                 |             |               |     |
| BTRY ABOVE MDP (Δh)                                           | -210         |                            | LINE NO                  | WIND DIR           | WIND SPEED             | AIR TEMP             | AIR DENSITY |               |     |
| ALT OF TARGET (nearest meter)                                 | 389          |                            | Δh CORRECTION            | 0.5                |                        | 2.1                  |             |               |     |
| WEIGHT OF BURST ABOVE TARGET                                  |              |                            | CORRECTED VALUES         | 101.3              |                        | 97.9                 |             |               |     |
| ALT OF BURST                                                  | 389          |                            |                          |                    |                        |                      |             |               |     |
| ALT OF BTRY (nearest meter)                                   | 336          |                            |                          |                    |                        |                      |             |               |     |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        | +53 ≈ +100   |                            | COMP RG +27              | CHART RG           | 5030                   | ENTRY RG             | 5057 ≈ 5100 |               |     |
| WIND COMPONENTS AND DEFLECTION                                |              |                            |                          |                    |                        |                      |             |               |     |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              | 6400         |                            |                          |                    |                        |                      |             |               |     |
| DIRECTION OF WIND                                             | 5900         |                            |                          |                    |                        |                      |             |               |     |
| (651)                                                         |              |                            |                          |                    |                        |                      |             |               |     |
| DIRECTION OF FIRE                                             | 700          |                            |                          |                    |                        |                      |             |               |     |
| CHART DIRECTION OF WIND                                       | 5200         |                            |                          |                    |                        |                      |             |               |     |
| CROSS WIND                                                    | WIND SPEED   | 17                         | x COMP                   | 0.92               | 16                     | KNOTS                | 0.17        | ROTATION CORR | L R |
| RANGE WIND                                                    | WIND SPEED   | 17                         | x COMP                   | 0.38               | 6                      | KNOTS                | 0.63        | DRIFT CORR    | L R |
| MET RANGE CORRECTION                                          |              |                            |                          |                    |                        |                      |             |               |     |
|                                                               | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS   | PLUS                   | MINUS                |             |               |     |
| RANGE WIND                                                    | 6            | 0                          | 6                        | +6.7               |                        |                      |             |               |     |
| AIR TEMP                                                      | 101.3        | 100%                       | 1.3                      | -1.9               |                        |                      |             |               |     |
| AIR DENSITY                                                   | 97.9         | 100%                       | 2.1                      | -5.8               |                        |                      |             |               |     |
| PROJ WEIGHT                                                   | 3            | 4                          | 1                        | -35                |                        |                      |             |               |     |
| ROTATION                                                      |              |                            |                          |                    |                        |                      |             |               |     |
| MET RANGE CORR                                                |              |                            |                          |                    |                        |                      |             |               |     |
| COMPUTATION OF VE                                             |              |                            |                          |                    |                        |                      |             |               |     |
| PROP TEMP                                                     | +82          | VE                         | M/S                      | D + 28.0           | TOTAL RANGE CORRECTION |                      |             |               |     |
|                                                               |              | CHANGE TO MV FOR PROP TEMP | +0.7                     | M/S                | I - 21.6               | MET RANGE CORRECTION |             |               |     |
|                                                               |              | ΔV                         | M/S                      | MV UNIT CORRECTION | ΔV RANGE CORRECTION    |                      |             |               |     |
| OLD VE                                                        |              |                            |                          |                    |                        |                      |             |               |     |

Figure 6-17. Entry of basic unit correction factors.

(2) *Table H.* This table lists corrections that are applied to range to compensate for Earth rotation. Table H is entered with the entry range to the nearest listed value in the left-hand column and the azimuth of fire (nearest mil) to the nearest listed value. If the azimuth is between 0 and 3200, the table is entered from the top. If it is between 3200 and 6400, it is entered from the bottom. The sign is minus when entering from the top and plus when entering from the bottom. The value extracted is for 0 degrees latitude and must be modified by a correction factor shown below the table. The correction factors are recorded as shown in figure 6-18.

FT 155-AM-1

PROJ. HE, M107  
FUZE, PD, M557

TABLE H

ROTATION - RANGE

CHARGE  
46CORRECTIONS TO RANGE, IN METERS, TO COMPENSATE  
FOR THE ROTATION OF THE EARTH

| RANGE<br>METERS | AZIMUTH OF TARGET - MILS |             |             |             |             |              |              |              |
|-----------------|--------------------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|
|                 | 0<br>3200                | 200<br>3000 | 400<br>2800 | 600<br>2600 | 800<br>2400 | 1000<br>2200 | 1200<br>2000 | 1400<br>1800 |
| 500             | 0                        | -1+         | -1+         | -2+         | -3+         | -3+          | -3+          | -4+          |
| 1000            | 0                        | -1+         | -3+         | -4+         | -5+         | -6+          | -7+          | -7+          |
| 1500            | 0                        | -2+         | -4+         | -6+         | -7+         | -9+          | -10+         | -10+         |
| 2000            | 0                        | -3+         | -5+         | -8+         | -10+        | -11+         | -13+         | -14+         |
| 2500            | 0                        | -3+         | -6+         | -9+         | -12+        | -14+         | -16+         | -17+         |
| 3000            | 0                        | -4+         | -8+         | -11+        | -14+        | -16+         | -18+         | -19+         |
| 3500            | 0                        | -4+         | -9+         | -13+        | -16+        | -19+         | -21+         | -23+         |
| 4000            | 0                        | -5+         | -10+        | -14+        | -18+        | -21+         | -23+         | -25+         |
| 4500            | 0                        | -5+         | -11+        | -15+        | -20+        | -23+         | -26+         | -28+         |
| 5000            | 0                        | -6+         | -11+        | -17+        | -21+        | -25+         | -28+         | -30+         |
| 5500            | 0                        | -6+         | -12+        | -18+        | -23+        | -27+         | -30+         | -32+         |
| 6000            | 0                        | -7+         | -13+        | -19+        | -24+        | -28+         | -31+         | -34+         |
| 6500            | 0                        | -7+         | -14+        | -20+        | -25+        | -30+         | -33+         | -36+         |
| 7000            | 0                        | -7+         | -14+        | -20+        | -26+        | -31+         | -34+         | -37+         |
| 7500            | 0                        | -7+         | -14+        | -21+        | -26+        | -31+         | -35+         | -37+         |
| 8000            | 0                        | -7+         | -14+        | -20+        | -26+        | -31+         | -34+         | -37+         |

- NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.  
2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.  
3. AZIMUTH IS MEASURED CLOCKWISE FROM NORTH.  
4. CORRECTIONS ARE FOR 0 DEGREES LATITUDE. FOR OTHER LATITUDES MULTIPLY CORRECTIONS BY THE FACTOR GIVEN BELOW.

| LATITUDE (DEG) | 10  | 20  | 30  | 40  | 50  | 60  | 70  |
|----------------|-----|-----|-----|-----|-----|-----|-----|
| MULTIPLY BY    | .98 | .94 | .87 | .77 | .64 | .50 | .34 |

| MET DATA CORRECTION SHEET                                     |                            |                 |                          |                  |                        |            |          |             |             |
|---------------------------------------------------------------|----------------------------|-----------------|--------------------------|------------------|------------------------|------------|----------|-------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                            |                 |                          |                  |                        |            |          |             |             |
| BATTERY DATA                                                  |                            |                 |                          |                  | MET MESSAGE            |            |          |             |             |
| CHARGE                                                        | ADJ. RC                    | CHART RC        | LATITUDE                 | TYPE MESSAGE     | OCTANT                 | AREA/UNIT  |          |             |             |
| 46A                                                           | 36                         | 5030            | 30°N                     | MEFB 3           | 1                      | 347985     |          |             |             |
| ALT OF BTRY (10m)                                             |                            | 340             |                          | DATE             | TIME                   | ALT MDP    | PRESSURE |             |             |
|                                                               |                            |                 |                          | 27               | 1230                   | 550        | 97.2     |             |             |
| ALT OF MDP                                                    |                            | 550             |                          | LINE NO.         | WIND DIR               | WIND SPEED | AIR TEMP | AIR DENSITY |             |
|                                                               |                            |                 |                          | 02               | 3900                   | 17         | 100.8    | 93.8        |             |
| BTRY ABOVE MDP (Ah)                                           |                            | -210            |                          | Ah CORRECTION    |                        | 0.5        |          | 2.1         |             |
| ALT OF TARGET (nearest meter)                                 |                            | 389             |                          | CORRECTED VALUES |                        | 101.3      |          | 97.9        |             |
| HEIGHT OF BURST ABOVE TARGET                                  |                            |                 |                          |                  |                        |            |          |             |             |
| ALT OF BURST                                                  |                            | 389             |                          |                  |                        |            |          |             |             |
| ALT OF BTRY (nearest meter)                                   |                            | 336             |                          |                  |                        |            |          |             |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |                            | +53 ≈ +100      |                          | COMP RC          | +27                    | CHART RC   | 5030     | ENTRY RC    | 5057 ≈ 5100 |
| WIND COMPONENTS AND DEFLECTION                                |                            |                 |                          |                  |                        |            |          |             |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |                            | 6400            |                          |                  |                        |            |          |             |             |
| DIRECTION OF WIND                                             |                            | 5900            |                          |                  |                        |            |          |             |             |
| (651)                                                         |                            |                 |                          |                  |                        |            |          |             |             |
| DIRECTION OF FIRE                                             |                            | 700             |                          |                  |                        |            |          |             |             |
| CHART DIRECTION OF WIND                                       |                            | 5200            |                          |                  |                        |            |          |             |             |
| CROSS WIND                                                    | WIND SPEED                 | 17              | COMP                     | 0.92             | 16                     | KNOTS      | 0.17     | CROSS WIND  | 0.63        |
| RANGE WIND                                                    | WIND SPEED                 | 17              | COMP                     | 0.38             | 6                      | KNOTS      |          | RANGE WIND  |             |
| MET RANGE CORRECTION                                          |                            |                 |                          |                  |                        |            |          |             |             |
|                                                               | KNOWN VALUES               | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                   | MINUS      |          |             |             |
| RANGE WIND                                                    | 6                          | 0               | 6                        | +6.7             |                        |            |          |             |             |
| AIR TEMP                                                      | 101.3                      | 100%            | 1.3                      | -1.9             |                        |            |          |             |             |
| AIR DENSITY                                                   | 97.9                       | 100%            | 2.1                      | -5.8             |                        |            |          |             |             |
| PROJ WEIGHT                                                   | 3                          | 4               | 1                        | -3.5             |                        |            |          |             |             |
| ROTATION                                                      |                            |                 | -17                      | .87              |                        |            |          |             |             |
| COMPUTATION OF VE                                             |                            |                 |                          |                  |                        |            |          |             |             |
| PROP TEMP                                                     | +82                        | VE              | M/S                      | D + 28.0         | TOTAL RANGE CORRECTION |            |          |             |             |
|                                                               | CHANGE TO MV FOR PROP TEMP | +0.7            | M/S                      | I - 21.6         | MET RANGE CORRECTION   |            |          |             |             |
|                                                               | AV                         |                 | M/S                      |                  | AV RANGE CORRECTION    |            |          |             |             |

Figure 6-18. Rotation correction (range).



(3) *Table I.* Table I lists correction factors to azimuth for rotation. Each page contains a table for the appropriate latitude. As with table H, the table is entered with the entry range and azimuth. For northern latitudes, the table is entered from the top; for southern latitudes, from the bottom. The sign before the number is used when entering from the top; the sign after the number is used when entering from the bottom. The appropriate value is extracted and recorded as shown in figure 6-19.

FT 155-AH-1  
PROJ. HE. M107  
FUZE. PD. M557

TABLE I  
ROTATION - AZIMUTH

CHARGE  
AG

CORRECTIONS TO AZIMUTH, IN MILS, TO COMPENSATE  
FOR THE ROTATION OF THE EARTH  
30 DEGREES NORTH LATITUDE

| RANGE<br>METERS | AZIMUTH OF TARGET - MILS |             |             |              |              |              |              |              |              |       |       |       |       |       |       |       |
|-----------------|--------------------------|-------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|-------|-------|-------|-------|-------|-------|-------|
|                 | 0<br>6400                | 400<br>6000 | 800<br>3600 | 1200<br>3200 | 1600<br>4800 | 2000<br>4400 | 2400<br>4000 | 2800<br>3600 | 3200<br>3200 |       |       |       |       |       |       |       |
| 900             | LO.1R                    | LO.1R       | LO.1R       | LO.1R        | LO.1R        | LO.1R        | LO.1R        | LO.1R        | LO.1R        | LO.1R | LO.1R | LO.1R | LO.1R | LO.1R | LO.1R | LO.1R |
| 1000            | LO.1R                    | LO.1R       | LO.1R       | LO.1R        | LO.1R        | LO.1R        | LO.1R        | LO.1R        | LO.1R        | LO.1R | LO.1R | LO.1R | LO.1R | LO.1R | LO.1R | LO.1R |
| 1500            | LO.2R                    | LO.2R       | LO.2R       | LO.2R        | LO.2R        | LO.2R        | LO.2R        | LO.2R        | LO.2R        | LO.2R | LO.2R | LO.2R | LO.2R | LO.2R | LO.2R | LO.2R |
| 2000            | LO.2R                    | LO.2R       | LO.2R       | LO.2R        | LO.2R        | LO.2R        | LO.2R        | LO.2R        | LO.2R        | LO.2R | LO.2R | LO.2R | LO.2R | LO.2R | LO.2R | LO.2R |
| 2500            | LO.3R                    | LO.3R       | LO.3R       | LO.3R        | LO.3R        | LO.3R        | LO.3R        | LO.3R        | LO.3R        | LO.3R | LO.3R | LO.3R | LO.3R | LO.3R | LO.3R | LO.3R |
| 3000            | LO.3R                    | LO.3R       | LO.3R       | LO.4R        | LO.4R        | LO.4R        | LO.4R        | LO.4R        | LO.4R        | LO.4R | LO.4R | LO.4R | LO.4R | LO.4R | LO.4R | LO.4R |
| 3500            | LO.4R                    | LO.4R       | LO.4R       | LO.4R        | LO.4R        | LO.4R        | LO.4R        | LO.4R        | LO.4R        | LO.4R | LO.4R | LO.4R | LO.4R | LO.4R | LO.4R | LO.4R |
| 4000            | LO.4R                    | LO.4R       | LO.4R       | LO.5R        | LO.5R        | LO.5R        | LO.5R        | LO.5R        | LO.5R        | LO.5R | LO.5R | LO.5R | LO.5R | LO.5R | LO.5R | LO.5R |
| 4500            | LO.5R                    | LO.5R       | LO.5R       | LO.5R        | LO.5R        | LO.5R        | LO.5R        | LO.5R        | LO.5R        | LO.5R | LO.5R | LO.5R | LO.5R | LO.5R | LO.5R | LO.5R |
| 5000            | LO.5R                    | LO.5R       | LO.5R       | LO.6R        | LO.6R        | LO.6R        | LO.6R        | LO.6R        | LO.6R        | LO.6R | LO.6R | LO.6R | LO.6R | LO.6R | LO.6R | LO.6R |
| 5500            | LO.6R                    | LO.6R       | LO.6R       | LO.6R        | LO.6R        | LO.6R        | LO.6R        | LO.6R        | LO.6R        | LO.6R | LO.6R | LO.6R | LO.6R | LO.6R | LO.6R | LO.6R |
| 6000            | LO.6R                    | LO.6R       | LO.6R       | LO.7R        | LO.7R        | LO.7R        | LO.7R        | LO.7R        | LO.7R        | LO.7R | LO.7R | LO.7R | LO.7R | LO.7R | LO.7R | LO.7R |
| 6500            | LO.7R                    | LO.7R       | LO.7R       | LO.7R        | LO.7R        | LO.7R        | LO.7R        | LO.7R        | LO.7R        | LO.7R | LO.7R | LO.7R | LO.7R | LO.7R | LO.7R | LO.7R |
| 7000            | LO.7R                    | LO.7R       | LO.7R       | LO.8R        | LO.8R        | LO.8R        | LO.8R        | LO.8R        | LO.8R        | LO.8R | LO.8R | LO.8R | LO.8R | LO.8R | LO.8R | LO.8R |

NOTES - 1. WHEN ENTERING FROM THE TOP USE THE SIGN BEFORE THE NUMBER.  
2. WHEN ENTERING FROM THE BOTTOM USE THE SIGN AFTER THE NUMBER.  
3. R DENOTES CORRECTION TO THE RIGHT; L TO THE LEFT.  
4. AZIMUTH IS MEASURED CLOCKWISE FROM THE NORTH.

| MET DATA CORRECTION SHEET                                     |                            |                 |                          |                    |                        |               |          |                   |  |
|---------------------------------------------------------------|----------------------------|-----------------|--------------------------|--------------------|------------------------|---------------|----------|-------------------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                            |                 |                          |                    |                        |               |          |                   |  |
| BATTERY DATA                                                  |                            |                 |                          |                    | MET MESSAGE            |               |          |                   |  |
| CHARGE                                                        | ADJ. OF                    | CHART RG        | LATITUDE                 | TYPE MESSAGE       | OCTANT                 | AREA/UNIT     |          |                   |  |
| 468                                                           | 316                        | 5030            | 30°N                     | METB 3             | 1                      | 347985        |          |                   |  |
| ALT OF BTRY (10m)                                             |                            | 340             |                          | DAY                | TIME                   | ALL MDP       | PRESSURE |                   |  |
|                                                               |                            |                 |                          | 02                 | 1230                   | 550           | 97.2     |                   |  |
| ALT OF MDP                                                    |                            | 550             |                          | LINE NO.           | WIND DIR               | WIND SPEED    | AIR TEMP | AIR DENSITY       |  |
|                                                               |                            |                 |                          | 02                 | 3900                   | 17            | 100.8    | 95.8              |  |
| BTRY ABOVE MDP (Δh)                                           |                            | -210            |                          | Δh CORRECTION      |                        |               | 0.5      | 2.1               |  |
| ALT OF TARGET (nearest meter)                                 |                            | 389             |                          | CORRECTED VALUES   |                        |               | 101.3    | 97.9              |  |
| HEIGHT OF BURST ABOVE TARGET                                  |                            |                 |                          |                    |                        |               |          |                   |  |
| ALT OF BURST                                                  |                            | 389             |                          |                    |                        |               |          |                   |  |
| ALT OF BTRY (nearest meter)                                   |                            | 336             |                          |                    |                        |               |          |                   |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |                            | +53 ≈ +100      |                          | COMP RG +27        | CHART RG 5030          | ENTRY RG 5057 | ≈ 5100   |                   |  |
| WIND COMPONENTS AND DEFLECTION                                |                            |                 |                          |                    |                        |               |          |                   |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |                            | 6400            |                          |                    |                        |               |          |                   |  |
| DIRECTION OF WIND                                             |                            | 5900            |                          |                    |                        |               |          |                   |  |
| (651)                                                         |                            |                 |                          |                    |                        |               |          |                   |  |
| DIRECTION OF FIRE                                             |                            | 700             |                          |                    |                        |               |          |                   |  |
| CHART DIRECTION OF WIND                                       |                            | 5200            |                          |                    |                        |               |          |                   |  |
| CROSS WIND                                                    | WIND SPEED                 | 17              | x COMP                   | 0.92               | 0.16                   | KNOTS         | 0.17     | CROSS WIND L CORR |  |
| RANGE WIND                                                    | WIND SPEED                 | 17              | x CORR                   | 0.38               | 0.06                   | KNOTS         | 0.06     | CROSS WIND R CORR |  |
| MET RANGE CORRECTION                                          |                            |                 |                          |                    |                        |               |          |                   |  |
|                                                               | KNOWN VALUES               | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS   | PLUS                   | MINUS         |          |                   |  |
| RANGE WIND                                                    | 6                          | 0               | 6                        | +6.7               |                        |               |          |                   |  |
| AIR TEMP                                                      | 101.3                      | 100%            | 1.3                      | -1.9               |                        |               |          |                   |  |
| AIR DENSITY                                                   | 97.9                       | 100%            | 2.1                      | -5.8               |                        |               |          |                   |  |
| PROJ WEIGHT                                                   | 30                         | 40              | 10                       | -35                |                        |               |          |                   |  |
| ROTATION                                                      |                            |                 | -17 x .87                |                    |                        |               |          |                   |  |
| MET RANGE CORR                                                |                            |                 |                          |                    |                        |               |          |                   |  |
| COMPUTATION OF VE                                             |                            |                 |                          |                    |                        |               |          |                   |  |
| PROP TEMP +82                                                 | VE                         |                 | M/S                      | D + 28.0           | TOTAL RANGE CORRECTION |               |          |                   |  |
|                                                               | CHANGE TO MV FOR PROP TEMP | +0.7            | M/S                      | I - 21.6           | MET RANGE CORRECTION   |               |          |                   |  |
|                                                               | ΔV                         |                 | M/S                      | MV UNIT CORRECTION | ΔV RANGE CORRECTION    |               |          |                   |  |
|                                                               |                            |                 |                          |                    | TOTAL RANGE CORRECTION |               |          |                   |  |

Figure 6-19. Rotation correction (azimuth).

**j. Compute (fig 6-20):**

(1) *Met deflection correction.* The crosswind unit correction factor (table F, column 8) is multiplied by the crosswind value and recorded as shown. The values for rotation, drift, and crosswind are then totaled and expressed to the

nearest mil. This value represents that part of the total deflection correction due to measurable (met) conditions.

**(2) Position deflection correction (constant).** The met deflection correction is subtracted from the total deflection correction to determine the position deflection correction (constant).

| MET DATA CORRECTION SHEET                                     |         |                            |           |                          |          |                    |  |                        |  |
|---------------------------------------------------------------|---------|----------------------------|-----------|--------------------------|----------|--------------------|--|------------------------|--|
| For use of this form, see FM 4-40; proponent agency is TRADOC |         |                            |           |                          |          |                    |  |                        |  |
| BATTERY DATA                                                  |         |                            |           | MET MESSAGE              |          |                    |  |                        |  |
| CHARGE                                                        | ADJ. DE | CHART RG                   | LATITUDE  | TYPE MESSAGE             | OCTANT   | AREA/UNIT          |  |                        |  |
| 408                                                           | 3/6     | 5030                       | 10° 16' N | MET 1330                 | 1        | 447985             |  |                        |  |
| ALT OF BTRY (10m)                                             |         |                            |           | DATE                     | TIME     | ALT MDP            |  | PRESSURE               |  |
| 340                                                           |         |                            |           | 27                       | 1230     | 550                |  | 872                    |  |
| ALT OF MDP                                                    |         |                            |           | LINE NO.                 | WIND DIR | WIND SPEED         |  | AIR TEMP               |  |
| 550                                                           |         |                            |           | 02                       | 5900     | 17                 |  | 100.8                  |  |
| BTRY ABOVE MDP (AIR)                                          |         |                            |           | AN CORRECTION            |          | 0.5                |  | 2.1                    |  |
| BELOW -210                                                    |         |                            |           | CORRECTED VALUES         |          | 101.3              |  | 97.9                   |  |
| ALT OF TARGET (nearest meter)                                 |         |                            |           |                          |          |                    |  |                        |  |
| 389                                                           |         |                            |           |                          |          |                    |  |                        |  |
| HEIGHT OF BURST ABOVE TARGET                                  |         |                            |           |                          |          |                    |  |                        |  |
| 389                                                           |         |                            |           |                          |          |                    |  |                        |  |
| ALT OF BTRY (nearest meter)                                   |         |                            |           |                          |          |                    |  |                        |  |
| 336                                                           |         |                            |           |                          |          |                    |  |                        |  |
| HEIGHT OF TARGET (nearest meter)                              |         |                            |           |                          |          |                    |  |                        |  |
| +53 ± 100                                                     |         |                            |           | COMP RG + 27             |          | CHART RG 5030      |  | ENTRY RG 5057 ± 5100   |  |
| WIND COMPONENTS AND DEFLECTION                                |         |                            |           |                          |          |                    |  |                        |  |
| WHEN DIRECTION OF WIND IS                                     |         |                            |           | 6400                     |          | TOT - MET = POS    |  |                        |  |
| WIND TYPEN OR FIRE ADD                                        |         |                            |           | 5900                     |          | R2 - L10 = R12     |  |                        |  |
| DIRECTION OF WIND                                             |         |                            |           | (651)                    |          |                    |  |                        |  |
| DIRECTION OF FIRE                                             |         |                            |           | 700                      |          |                    |  |                        |  |
| CHART DIRECTION OF WIND                                       |         |                            |           | 5200                     |          |                    |  |                        |  |
| CROSS WIND SPEED                                              |         |                            |           | 17                       |          | COMP 0.92          |  | KNOTS 0.17             |  |
| WIND SPEED                                                    |         |                            |           | 17                       |          | COMP 0.38          |  | KNOTS 6                |  |
| RANGE WIND                                                    |         |                            |           | 17                       |          | COMP 0.38          |  | KNOTS 6                |  |
|                                                               |         |                            |           |                          |          |                    |  |                        |  |
| MET RANGE CORRECTION                                          |         |                            |           |                          |          |                    |  |                        |  |
| KNOWN VALUES                                                  |         | STANDARD VALUES            |           | VARIATIONS FROM STANDARD |          | UNIT CORRECTIONS   |  | PLUS MINUS             |  |
| RANGE WIND 6                                                  |         | 0                          |           | 0.6                      |          | +6.7               |  |                        |  |
| AIR TEMP 101.3                                                |         | 100%                       |           | 1.3                      |          | -1.9               |  |                        |  |
| AIR DENSITY 97.9                                              |         | 100%                       |           | 2.1                      |          | -5.8               |  |                        |  |
| PROJ WEIGHT 30                                                |         | 40                         |           | 10                       |          | -3.5               |  |                        |  |
| ROTATION                                                      |         | -17                        |           | x.87                     |          |                    |  |                        |  |
| MET RANGE CORR                                                |         |                            |           |                          |          |                    |  |                        |  |
| COMPUTATION OF VE                                             |         |                            |           |                          |          |                    |  |                        |  |
| PROP TEMP +82 °F                                              |         | VE                         |           | M/S                      |          | D + 28.0           |  | TOTAL RANGE CORRECTION |  |
|                                                               |         | CHANGE TO MV FOR PROP TEMP |           | M/S                      |          | I - 21.6           |  | MET RANGE CORRECTION   |  |
|                                                               |         | A V                        |           | M/S                      |          | SV UNIT CORRECTION |  | A V RANGE CORRECTION   |  |
|                                                               |         |                            |           |                          |          |                    |  | TOTAL RANGE CORRECTION |  |
| OLD VE                                                        |         | + NEW VE                   |           | =                        |          | + 3 AVG VE         |  | M/S                    |  |

|               |   |               |  |  |  |   |  |                       |  |                |  |
|---------------|---|---------------|--|--|--|---|--|-----------------------|--|----------------|--|
| AIR TEMP      | D |               |  |  |  |   |  |                       |  |                |  |
| AIR DENSITY   | D |               |  |  |  |   |  |                       |  |                |  |
| PROJ WEIGHT   | D |               |  |  |  |   |  |                       |  |                |  |
|               |   |               |  |  |  |   |  | TOTAL FUZE CORRECTION |  |                |  |
|               |   |               |  |  |  |   |  | MET FUZE CORRECTION   |  |                |  |
|               |   |               |  |  |  |   |  | FUZE CORRECTION       |  |                |  |
|               |   |               |  |  |  |   |  | TOTAL FUZE CORRECTION |  |                |  |
| MET FUZE CORR |   |               |  |  |  |   |  |                       |  |                |  |
| OLD FZ CORR   |   | + NEW FZ CORR |  |  |  | = |  |                       |  | +2-AVG FZ CORR |  |
| TARGET NO.    |   | BATTERY       |  |  |  |   |  | DATE/TIME             |  |                |  |

DA FORM 7-4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
JAN 74 \* U.S. G.P.O. 1977-765037/45

**Figure 6-20. Met deflection correction.**

k. Compute (fig 6-21):

★ (1) *Met range correction.* The variations from standard in the MET RANGE CORRECTION block are multiplied by the unit correction factors and these values are recorded in the proper column (to the nearest 0.1). The columns are added, the smaller value algebraically added to the larger and the result expressed to the nearest meter and recorded as shown.

★ (2) *Position VE.* The total range correction represents the correction for all nonstandard conditions. The met range correction represents the correction for met nonstandard conditions. The  $\Delta V$  range correction represents what is left and is determined by algebraically subtracting the met range correction from the total range correction. The symbol  $\Delta V$  represents the total variation from the standard muzzle velocity and the  $\Delta V$  range correction represents the magnitude of the correction in meters required to offset the variation in muzzle velocity. Since muzzle velocity is measured in meters per second (m/s), the  $\Delta V$  range correction must be converted from meters to meters per second to express the total variation from standard ( $\Delta V$ ). The conversion is accomplished by dividing the  $\Delta V$  range correction by the appropriate muzzle velocity unit correction factor extracted from table F. To determine which correction factor to use, the  $\Delta V$  range correction must be fully understood. A positive  $\Delta V$  range correction shows that an increase in range was needed; it follows that the velocity developed was not enough to achieve the range desired. Therefore, the

muzzle velocity was less than standard or a decrease. Since the velocity was a decrease, the decrease unit correction factor will be used. The unit correction factor indicates how many meters per-second decrease from the standard. (When the muzzle velocity decreases from standard, a plus range correction is needed; when the muzzle velocity increases from standard, a minus range correction is necessary.) In this problem, a plus  $\Delta V$  range correction has been determined (+114) indicating a decrease in muzzle velocity. To determine how much of a decrease in muzzle velocity, the unit correction factor (+28.0) is divided into +114. The answer is expressed to the nearest one-tenth of a meter per second. Since the muzzle velocity has been determined to be a decrease from standard, the variation must be a minus, yielding a -4.1  $\Delta V$ .  $\Delta V$  represents the *total* variation from the standard muzzle velocity. This total variation is made up of two parts, propellant temperature effect, which can be measured, and the position velocity error, which is due to elements that cannot be easily measured (e.g., chart errors, survey errors, tube wear, and projectile ballistic coefficient). Since the total ( $\Delta V$ ) is known (-4.1) and a part (+0.7) which is due to propellant temperature is known, the remaining part (VE) can be determined by algebraically subtracting the change to MV for propellant temperature from  $\Delta V$ . The resultant position VE is a "constant" that may change over an extended period of time but is considered a constant until a new position VE is determined from a later registration and concurrent met.

| MET DATA CORRECTION SHEET                                     |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
|---------------------------------------------------------------|--------------|----------------------------|--------------------------|------------------|--------------------------|------------------------|------|-----------------|-------------|----------|-------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
| BATTERY DATA                                                  |              |                            |                          |                  | MET MESSAGE              |                        |      |                 |             |          |       |
| CHARGE                                                        | ADJ DE       | CHART RG                   | LATITUDE                 | TYPE MESSAGE     | OCTANT                   | AREA/UNIT              |      |                 |             |          |       |
| 468                                                           | 316          | 5030                       | 30°N                     | METB.3           | 1                        | 347985                 |      |                 |             |          |       |
| ALT OF BTRY (10m)                                             |              | 340                        |                          | DATE             | 27                       | TIME                   | 1230 | ALT MDP         | 550         | PRESSURE | 972   |
| ALT OF MDP                                                    |              | 550                        |                          | LINE NO          | 02                       | WIND DIR               | 5900 | WIND SPEED      | 17          | AIR TEMP | 100.8 |
| BTRY ABOVE MDP (Δh)                                           |              | -210                       |                          | Δh CORRECTION    |                          | 0.5                    |      | 0.5             |             | 95.8     |       |
| ALT OF TARGET (nearest meter)                                 |              | 389                        |                          | CORRECTED VALUES |                          | 101.3                  |      | 97.9            |             |          |       |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
| ALT OF BURST                                                  |              | 389                        |                          |                  |                          |                        |      |                 |             |          |       |
| ALT OF BTRY (nearest meter)                                   |              | 336                        |                          |                  |                          |                        |      |                 |             |          |       |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              | +53 ≈ +100                 |                          | COMP RG          | +27                      | CHART RG               | 5030 | ENTRY RG        | 5057 ≈ 5100 |          |       |
| WIND COMPONENTS AND DEFLECTION                                |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400                       |                          | TOT - MET = POS  |                          |                        |      |                 |             |          |       |
| DIRECTION OF WIND                                             |              | 5900                       |                          | R2 - L10 = R12   |                          |                        |      |                 |             |          |       |
| (651)                                                         |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
| DIRECTION OF FIRE                                             |              | 700                        |                          |                  |                          |                        |      |                 |             |          |       |
| CHART DIRECTION OF WIND                                       |              | 5200                       |                          |                  |                          |                        |      |                 |             |          |       |
| CROSS WIND                                                    | WIND SPEED   | 17                         | * COMP                   | 0.92             | 0.16                     | KNOTS                  | 0.17 | ROTATION CORR   | 0.6         |          |       |
| RANGE WIND                                                    | WIND SPEED   | 17                         | * COMP                   | 0.38             | 0.06                     | KNOTS                  | 0.06 | DRIFT CORR      | 0.63        |          |       |
|                                                               |              |                            |                          |                  |                          |                        |      | CROSS WIND CORR | 2.7         |          |       |
|                                                               |              |                            |                          |                  |                          |                        |      | MET DEFL CORR   | 9.6 ≈ L10   |          |       |
| MET RANGE CORRECTION                                          |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
|                                                               | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                     | MINUS                  |      |                 |             |          |       |
| RANGE WIND                                                    | 6            | 0                          | 6                        | +6.7             | 40.2                     |                        |      |                 |             |          |       |
| AIR TEMP                                                      | 101.3        | 100%                       | 1.3                      | -1.9             |                          | 2.5                    |      |                 |             |          |       |
| AIR DENSITY                                                   | 97.9         | 100%                       | 2.1                      | -5.8             |                          | 12.2                   |      |                 |             |          |       |
| PROJ WEIGHT                                                   | 3            | 4                          | 1                        | -3.5             |                          | 35.0                   |      |                 |             |          |       |
| ROTATION                                                      |              |                            | -17 × .87                |                  |                          | 14.8                   |      |                 |             |          |       |
|                                                               |              |                            |                          |                  | 40.2                     | 64.5                   |      |                 |             |          |       |
|                                                               |              |                            |                          |                  |                          | 40.2                   |      |                 |             |          |       |
|                                                               |              |                            |                          |                  |                          | 24.3 ≈ -24             |      |                 |             |          |       |
| COMPUTATION OF VE                                             |              |                            |                          |                  |                          |                        |      |                 |             |          |       |
| PROP TEMP                                                     | +82          | VE                         | -4.8                     | M/S              | D+28.0                   | TOTAL RANGE CORRECTION | +90  |                 |             |          |       |
|                                                               |              | CHANGE TO MV FOR PROP TEMP | +0.7                     | M/S              | I-21.6                   | MET RANGE CORRECTION   | -24  |                 |             |          |       |
|                                                               |              | ΔV                         | -4.1                     | M/S              | MV UNIT CORRECTION +28.0 | ΔV RANGE CORRECTION    | +114 |                 |             |          |       |
|                                                               |              |                            |                          |                  |                          | TOTAL RANGE CORRECTION |      |                 |             |          |       |

Figure 6-21. Met range correction.

1. Enter tables (fig 6-22). Enter variations from standard in the Met Fuze Correction block and determine corrections from table J. The table is entered with the fuze setting corresponding to the adjusted elevation expressed to the nearest whole fuze setting increment. The values are extracted from the appropriate increase or decrease column.

| CHARGE<br>4G |                             | TABLE J<br>FUZE CORRECTION FACTORS |                         |      |                      |      |                         |       |                                  |       |  | FT 155-AM-1<br>PROJ, ME, M107<br>FUZE, MTSQ, M564 |
|--------------|-----------------------------|------------------------------------|-------------------------|------|----------------------|------|-------------------------|-------|----------------------------------|-------|--|---------------------------------------------------|
| 1            | 2                           | 3                                  | 4                       | 5    | 6                    | 7    | 8                       | 9     | 10                               | 11    |  |                                                   |
| FS           | FUZE CORRECTIONS FOR        |                                    |                         |      |                      |      |                         |       |                                  |       |  |                                                   |
|              | MUZZLE<br>VELOCITY<br>1 M/S |                                    | RANGE<br>WIND<br>1 KNOT |      | AIR<br>TEMP<br>1 PCT |      | AIR<br>DENSITY<br>1 PCT |       | PROJ WT<br>OF 1 SQ<br>(4 SQ STD) |       |  |                                                   |
|              | DEC                         | INC                                | HEAD                    | TAIL | DEC                  | INC  | DEC                     | INC   | DEC                              | INC   |  |                                                   |
| 0            |                             |                                    |                         |      |                      |      |                         |       |                                  |       |  |                                                   |
| 1            |                             |                                    |                         |      |                      |      |                         |       |                                  |       |  |                                                   |
| 2            | -.006                       | .006                               | .000                    | .000 | -.001                | .000 | .000                    | .000  | .010                             | -.011 |  |                                                   |
| 3            | -.009                       | .009                               | -.001                   | .000 | -.002                | .001 | .000                    | .000  | .015                             | -.015 |  |                                                   |
| 4            | -.012                       | .011                               | -.001                   | .000 | -.003                | .001 | .000                    | .000  | .019                             | -.020 |  |                                                   |
| 5            | -.015                       | .013                               | -.002                   | .000 | -.004                | .001 | .001                    | -.001 | .024                             | -.025 |  |                                                   |
| 6            | -.018                       | .016                               | -.002                   | .000 | -.006                | .001 | .001                    | -.001 | .028                             | -.029 |  |                                                   |
| 7            | -.021                       | .018                               | -.003                   | .000 | -.007                | .001 | .001                    | -.001 | .032                             | -.034 |  |                                                   |
| 8            | -.024                       | .020                               | -.003                   | .001 | -.009                | .001 | .002                    | -.001 | .036                             | -.038 |  |                                                   |
| 9            | -.026                       | .023                               | -.004                   | .001 | -.010                | .002 | .002                    | -.002 | .040                             | -.042 |  |                                                   |
| 10           | -.029                       | .025                               | -.004                   | .001 | -.012                | .002 | .002                    | -.002 | .044                             | -.046 |  |                                                   |
| 11           | -.032                       | .027                               | -.005                   | .001 | -.013                | .002 | .002                    | -.002 | .048                             | -.050 |  |                                                   |
| 12           | -.035                       | .029                               | -.006                   | .001 | -.015                | .002 | .003                    | -.003 | .051                             | -.055 |  |                                                   |
| 13           | -.038                       | .032                               | -.006                   | .001 | -.016                | .003 | .003                    | -.003 | .055                             | -.059 |  |                                                   |
| 14           | -.040                       | .034                               | -.007                   | .001 | -.017                | .003 | .004                    | -.004 | .059                             | -.063 |  |                                                   |
| 15           | -.043                       | .036                               | -.007                   | .001 | -.018                | .003 | .004                    | -.004 | .063                             | -.067 |  |                                                   |
| 16           | -.046                       | .039                               | -.008                   | .002 | -.020                | .003 | .005                    | -.005 | .066                             | -.071 |  |                                                   |
| 17           | -.049                       | .041                               | -.008                   | .002 | -.021                | .003 | .005                    | -.005 | .070                             | -.075 |  |                                                   |
| 18           | -.051                       | .043                               | -.009                   | .002 | -.022                | .003 | .006                    | -.006 | .074                             | -.079 |  |                                                   |
| 19           | -.054                       | .046                               | -.009                   | .002 | -.023                | .004 | .006                    | -.006 | .077                             | -.082 |  |                                                   |
| 20           | -.057                       | .048                               | -.009                   | .002 | -.024                | .004 | .007                    | -.007 | .081                             | -.086 |  |                                                   |
| 21           | -.061                       | .051                               | -.012                   | .002 | -.025                | .005 | .007                    | -.007 | .085                             | -.090 |  |                                                   |
| 22           | -.064                       | .054                               | -.012                   | .002 | -.026                | .005 | .008                    | -.008 | .089                             | -.094 |  |                                                   |
| 23           | -.067                       | .057                               | -.013                   | .003 | -.027                | .005 | .009                    | -.009 | .093                             | -.098 |  |                                                   |
| 24           | -.070                       | .060                               | -.013                   | .003 | -.028                | .005 | .010                    | -.010 | .097                             | -.102 |  |                                                   |
| 25           | -.073                       | .063                               | -.013                   | .003 | -.029                | .005 | .011                    | -.011 | .101                             | -.106 |  |                                                   |
| 26           | -.076                       | .066                               | -.013                   | .004 | -.030                | .005 | .012                    | -.012 | .105                             | -.110 |  |                                                   |
| 27           | -.079                       | .069                               | -.013                   | .004 | -.031                | .005 | .013                    | -.013 | .109                             | -.114 |  |                                                   |
| 28           | -.082                       | .072                               | -.013                   | .004 | -.032                | .005 | .014                    | -.014 | .113                             | -.118 |  |                                                   |
| 29           | -.085                       | .075                               | -.013                   | .004 | -.033                | .005 | .015                    | -.015 | .117                             | -.122 |  |                                                   |
| 30           | -.088                       | .078                               | -.013                   | .004 | -.034                | .005 | .016                    | -.016 | .121                             | -.126 |  |                                                   |
| 31           | -.091                       | .081                               | -.013                   | .004 | -.035                | .005 | .017                    | -.017 | .125                             | -.130 |  |                                                   |
| 32           | -.094                       | .084                               | -.013                   | .004 | -.036                | .005 | .018                    | -.018 | .129                             | -.134 |  |                                                   |
| 33           | -.097                       | .087                               | -.013                   | .004 | -.037                | .005 | .019                    | -.019 | .133                             | -.138 |  |                                                   |
| 34           | -.099                       | .089                               | -.013                   | .004 | -.038                | .005 | .020                    | -.020 | .137                             | -.142 |  |                                                   |
| 35           | -.102                       | .092                               | -.013                   | .004 | -.039                | .005 | .021                    | -.021 | .141                             | -.146 |  |                                                   |

| MET RANGE CORRECTION                        |                 |                            |                             |                     |                          |                        |
|---------------------------------------------|-----------------|----------------------------|-----------------------------|---------------------|--------------------------|------------------------|
|                                             | KNOWN<br>VALUES | STANDARD<br>VALUES         | VARIATIONS FROM<br>STANDARD | UNIT<br>CORRECTIONS | PLUS                     | MINUS                  |
| RANGE WIND                                  | 6               | 0                          | 6                           | +6.7                | 40.2                     |                        |
| AIR TEMP                                    | 101.3           | 100%                       | 1.3                         | -1.9                |                          | 2.5                    |
| AIR DENSITY                                 | 97.9            | 100%                       | 2.1                         | -5.8                |                          | 12.2                   |
| PROJ WEIGHT                                 | 3               | 4                          | 1                           | -35                 |                          | 35.0                   |
| ROTATION                                    |                 |                            | -17                         | .87                 |                          | 14.8                   |
|                                             |                 |                            |                             |                     | 40.2                     | 64.5                   |
|                                             |                 |                            |                             |                     |                          | 40.2                   |
|                                             |                 |                            |                             |                     |                          | 24.3                   |
| MET RANGE CORR                              |                 |                            |                             |                     |                          |                        |
| COMPUTATION OF VE                           |                 |                            |                             |                     |                          |                        |
| PROP TEMP                                   | +82             | VE                         | -4.8                        | M/S                 | D+28.0                   | TOTAL RANGE CORRECTION |
|                                             |                 | CHANGE TO MV FOR PROP TEMP | +0.7                        | M/S                 | I-21.6                   | MET RANGE CORRECTION   |
|                                             |                 | ΔV                         | -4.1                        | M/S                 | MV UNIT CORRECTION +28.0 | ΔV RANGE CORRECTION    |
|                                             |                 |                            |                             |                     |                          | TOTAL RANGE CORRECTION |
| OLD VE + NEW VE ÷ 2 = AVG VE                |                 |                            |                             |                     |                          |                        |
| FS ~ EL 304 / 8.4 ~ 18 MET FUZE CORRECTION  |                 |                            |                             |                     |                          |                        |
| ΔV                                          | 4.1             | VARIATION FROM STANDARD    | -0.051                      | UNIT CORRECTION     | PLUS                     | MINUS                  |
| RANGE WIND                                  | 6               |                            | -0.009                      |                     |                          |                        |
| AIR TEMP                                    | 1.3             |                            | +0.003                      |                     |                          |                        |
| AIR DENSITY                                 | 2.1             |                            | +0.006                      |                     |                          |                        |
| PROJ WEIGHT                                 | 1               |                            | +0.074                      |                     |                          |                        |
|                                             |                 |                            |                             |                     |                          | TOTAL FUZE CORRECTION  |
|                                             |                 |                            |                             |                     |                          | MET FUZE CORRECTION    |
|                                             |                 |                            |                             |                     |                          | FUZE CORRECTION        |
|                                             |                 |                            |                             |                     |                          | TOTAL FUZE CORRECTION  |
| MET FUZE CORR                               |                 |                            |                             |                     |                          |                        |
| OLD FZ CORR + NEW FZ CORR ÷ 2 = AVG FZ CORR |                 |                            |                             |                     |                          |                        |
| TARGET NO                                   | BATTERY         |                            | DATE/TIME                   |                     |                          |                        |

DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
\* U.S. G.P.

Figure 6-22. Fuze correction factors.

m. Compute (fig 6-23).

(1) *Met fuze correction.* The met fuze correction is determined in the same manner as the met range correction. See figure 6-13.

★ (2) *Position fuze correction (constant).* The position fuze correction is determined by algebraically subtracting the met fuze correction from the total fuze correction as shown.



Note. The position fuze correction (constant) determined should be considered a fuze characteristic, not a correction for existing weather conditions.

| MET DATA CORRECTION SHEET                                     |              |                            |                          |                  |                          |                        |          |                 |             |
|---------------------------------------------------------------|--------------|----------------------------|--------------------------|------------------|--------------------------|------------------------|----------|-----------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                            |                          |                  |                          |                        |          |                 |             |
| BATTERY DATA                                                  |              |                            |                          |                  | MET MESSAGE              |                        |          |                 |             |
| CHARGE                                                        | ADJ. OF      | CHART RG                   | LATITUDE                 | TYPE MESSAGE     | OCTANT                   | AREA UNIT              |          |                 |             |
| 448                                                           | 316          | 5030                       | 30°N                     | MET 8 3          | 1                        | 347985                 |          |                 |             |
| ALT OF BTRY (10m)                                             |              | 340                        |                          | DATE             | TIME                     | 1230                   | ALL WIND | PRESSURE        |             |
| ALT OF MDP                                                    |              | 550                        |                          | LINE NO.         | WIND DIR                 | WIND SPEED             | AIR TEMP | AIR DENSITY     |             |
| BTRY ABOVE MDP (Ah)                                           |              | -210                       |                          | Δh CORRECTION    | 0.5                      |                        | 0.5      | 2.1             |             |
| ALT OF TARGET (nearest meter)                                 |              | 389                        |                          | CORRECTED VALUES |                          | 101.3                  | 97.9     |                 |             |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                            |                          |                  |                          |                        |          |                 |             |
| ALT OF BURST                                                  |              | 389                        |                          |                  |                          |                        |          |                 |             |
| ALT OF BTRY (nearest meter)                                   |              | 336                        |                          |                  |                          |                        |          |                 |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (m)                        |              | +53 ≈ +100                 |                          | COMP RG          | +27                      | CHART RG               | 5030     | ENTRY RG        | 5057 ≈ 5100 |
| WIND COMPONENTS AND DEFLECTION                                |              |                            |                          |                  |                          |                        |          |                 |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400                       |                          | TOT-MET=POS      |                          |                        |          |                 |             |
| DIRECTION OF WIND                                             |              | 5900                       |                          | R2-L10=R12       |                          |                        |          |                 |             |
| (651)                                                         |              | 700                        |                          |                  |                          |                        |          |                 |             |
| DIRECTION OF FIRE                                             |              | 5200                       |                          |                  |                          |                        |          |                 |             |
| CHART DIRECTION OF WIND                                       |              | 5200                       |                          |                  |                          |                        |          |                 |             |
| CROSS WIND                                                    | WIND SPEED   | 17                         | *COMP                    | 0.92             | 0.16                     | KNOTS                  | 0.19     | ROTATION CORR   | 0.6         |
| RANGE WIND                                                    | WIND SPEED   | 17                         | *COMP                    | 0.38             | 0.6                      | KNOTS                  | 0.6      | DRIFT CORR      | 0.6         |
|                                                               |              |                            |                          |                  |                          |                        |          | CROSS WIND CORR | 0.27        |
|                                                               |              |                            |                          |                  |                          |                        |          | MET DEF CORR    | 0.6 ≈ L10   |
| MET RANGE CORRECTION                                          |              |                            |                          |                  |                          |                        |          |                 |             |
|                                                               | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                     | MINUS                  |          |                 |             |
| RANGE WIND                                                    | 6            | 0                          | 6                        | +6.7             | 40.2                     |                        |          |                 |             |
| AIR TEMP                                                      | 101.3        | 100%                       | 1.3                      | -1.9             |                          | 2.5                    |          |                 |             |
| AIR DENSITY                                                   | 97.9         | 100%                       | 2.1                      | -5.8             |                          | 12.2                   |          |                 |             |
| PROJ WEIGHT                                                   | 3            | 4                          | 1                        | -35              |                          | 35.0                   |          |                 |             |
| ROTATION                                                      |              |                            | -17 × .87                |                  |                          | 14.8                   |          |                 |             |
|                                                               |              |                            |                          |                  | 40.2                     | 64.5                   |          |                 |             |
|                                                               |              |                            |                          |                  | 40.2                     |                        |          |                 |             |
|                                                               |              |                            |                          |                  | 24.3 ≈ -24               |                        |          |                 |             |
| COMPUTATION OF VE                                             |              |                            |                          |                  |                          |                        |          |                 |             |
| PROP TEMP                                                     | +82          | VE                         | -4.8                     | M/S              | D+28.0                   | TOTAL RANGE CORRECTION | +90      |                 |             |
|                                                               |              | CHANGE TO MV FOR PROP TEMP | +0.7                     | M/S              | I-21.6                   | MET RANGE CORRECTION   | -24      |                 |             |
|                                                               |              | ΔV                         | -4.1                     | M/S              | MV UNIT CORRECTION +28.0 | ΔV RANGE CORRECTION    | +114     |                 |             |
| OLD VE                                                        |              | + NEW VE                   |                          | +7=AVG VE        |                          | M/S                    |          |                 |             |
| FS~EL304=18.4 ≈ 18 MET FUZE CORRECTION                        |              |                            |                          |                  |                          |                        |          |                 |             |
| ΔV                                                            | 4.1          | VARIATION FROM STANDARD    | -0.051                   | PLUS             | MINUS                    | 5120                   |          |                 |             |
| RANGE WIND                                                    | 6            |                            | -0.009                   |                  | 0.209                    | 5030 EL 304 T 18.7     |          |                 |             |
| AIR TEMP                                                      | 1.3          |                            | +0.003                   |                  | 0.004                    | 18.4                   |          |                 |             |
| AIR DENSITY                                                   | 2.1          |                            | +0.006                   |                  | 0.013                    |                        |          |                 |             |
| PROJ WEIGHT                                                   | 1            |                            | +0.074                   |                  | 0.074                    |                        |          |                 |             |
|                                                               |              |                            |                          |                  | 0.091                    | TOTAL FUZE CORRECTION  | +0.3     |                 |             |
|                                                               |              |                            |                          |                  | 0.091                    | MET FUZE CORRECTION    | -0.2     |                 |             |
|                                                               |              |                            |                          |                  | 0.091                    | FUZE CORRECTION        | +0.5     |                 |             |
|                                                               |              |                            |                          |                  | 0.172                    | TOTAL FUZE CORRECTION  |          |                 |             |
| MET FUZE CORR                                                 |              |                            |                          |                  |                          |                        |          |                 |             |
| OLD FZ CORR                                                   |              | + NEW FZ CORR              |                          | =                |                          | -7=AVG FZ CORR         |          | M/S             |             |
| TARGET NO.                                                    |              | BATTERY                    |                          | DATE TIME        |                          |                        |          |                 |             |

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 JAN 74 • U.S. G.P.O. 1977-765037/45

Figure 6-23. Met fuze correction.

## ★ 6-10. Position Constants

The purpose in solving a concurrent met is to isolate the position constants. These constants can be used later with subsequent mets to obtain MET + VE GFT settings without the need for conducting a subsequent registration.

a. Any time a registration is fired and a concurrent met (valid ballistic met) is available, the met will be solved to determine position constants. The first time a concurrent met is solved in a position, there is one set of position constants. The next time a concurrent met is solved, there will be two sets of position constants. Whenever new position constants are determined, they are averaged with the old position constants (or old average position constants) to determine the new average position constants to be used to solve subsequent mets.

*Example:*

Position velocity error (VE) determined at 0815 is -5.4 m/s.

Position VE determined at 1330 is -5.9 m/s.

Average position VE to be used after 1330 is -5.6 m/s.

$$\frac{(-5.4) + (-5.9)}{2} = \frac{-11.3}{2} = -5.65 \approx -5.6$$

Position VE determined at 1730 is -6.8 m/s.  
Average position VE to be used after 1730 is -6.2 m/s.

$$\frac{(-5.6) + (-6.8)}{2} = \frac{-12.4}{2} = -6.2$$

Position deflection constants and position fuze constants are averaged in the same manner as the position VE.

b. Position constants are considered valid only for the position, weapon, charge, and ammunition lot for which they are determined. When a unit has displaced to a new position and cannot register immediately, the average position VE and average position fuze constant from the last position may be used as a basis to determine a met + VE GFT setting by solving a subsequent met. Use of this technique may incur inaccuracies, but it will produce the most accurate data possible until a registration can be conducted. As soon as possible, new position constants should be determined in the new position. Once a registration is fired, the average position constants from the old position should not be used again.

*Note.* The position deflection constant should not be transferred from an old position to a new position unless common survey directional control exists between positions.

## Section IV. SUBSEQUENT MET

A subsequent met is solved to determine a new GFT setting when registration is not possible. Solving a subsequent met produces new met corrections, which are added to the position corrections determined from the concurrent met. Adding the met and position corrections yields new total corrections that are used to determine a new GFT setting. Paragraph 6-11 lists the recommended sequence for solving a subsequent met.

### 6-11. Sequence for Solution of a Subsequent Met

- a. Enter position constants.
- b. Enter known data.

c. Enter met line number and met message data.

\*d. Compute  $\Delta h$  and height of target above gun.

e. Compute chart direction of wind.

f. Enter tables and determine:

\* (1) Complementary range from table B.

(2) Wind components from table C.

\* (3) Corrections to temperature and density from table D.

(4) Correction to muzzle velocity for propellant temperature from table E.

\*g. Compute corrected values for temperature, density, and entry range.

h. Compute crosswind and rangewind.

i. Compute variations from standard.

j. Enter tables and determine:

\* (1) Unit corrections from table F.

\* (2) Rotation corrections for range from table H.

\* (3) Rotation corrections for azimuth from table I.

k. Compute met deflection correction and total deflection correction.

l. Compute met range correction, total range correction, and adjusted elevation.

m. Enter variations from standard in Met Fuze Correction block and determine corrections from table J.

n. Compute met fuze correction and total fuze correction.

o. Determine GFT setting.

*Note.* Asterisks indicate those values that may be the same as the concurrent met if the battery and met station have not moved.

## 6-12. Solution of a Subsequent Met

The sample problem below describes the solution of a subsequent met using the steps

outlined in paragraph 6-11. The position constants and known data from paragraph 6-9 will be used. The following met message is valid:

MET31 342988 271450 029088

002216 951036

012320 950040

022621 942052

032921 941051

043125 943050

Prop temp +65° F.

a. *Enter position constants.* The position deflection correction, the position VE, and the position fuze correction are entered as in figure 6-24.

| MET DATA CORRECTION SHEET                                     |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
|---------------------------------------------------------------|-------------------------|--------------------------|--------------------|------------------|-----------------------|------------------------|---------------------|-------------------|--|--|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| BATTERY DATA                                                  |                         |                          |                    |                  |                       | MET MESSAGE            |                     |                   |  |  |  |
| CHARGE                                                        | ADJ DE                  | CHART RC                 | LATITUDE           | TYPE MESSAGE     | OCTANT                | AREA/UNIT              |                     |                   |  |  |  |
| ALT OF BTRY (ftm)                                             |                         |                          |                    | DATE             | TIME                  | ALT MDP                | PRESSURE            |                   |  |  |  |
| ALT OF MDP                                                    |                         |                          |                    | LINE NO          | WIND DIR              | WIND SPEED             | AIR TEMP            | AIR DENSITY       |  |  |  |
| BTRY ABOVE MDP (ftm)                                          |                         |                          |                    | AN CORRECTION    |                       | Z                      |                     | Z                 |  |  |  |
| ALT OF TARGET (nearest meter)                                 |                         |                          |                    | CORRECTED VALUES |                       |                        |                     |                   |  |  |  |
|                                                               |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| WIND COMPONENTS AND DEFLECTION                                |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD 6400         |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| DIRECTION OF WIND                                             |                         |                          |                    |                  |                       | TOT = MET + POS + R/2  |                     |                   |  |  |  |
| DIRECTION OF FIRE                                             |                         |                          |                    |                  |                       | ROTATION CORR L R      |                     |                   |  |  |  |
| CHART DIRECTION OF WIND                                       |                         |                          |                    |                  |                       | DRIFT CORR L R         |                     |                   |  |  |  |
| CROSS WIND SPEED                                              | *COMP L                 | L                        | KNOTS              |                  | *UNIT CORR            | CROSS WIND L CORR R    |                     | MET DEFL CORR L R |  |  |  |
| RANG WIND SPEED                                               | *COMP H                 | H                        | KNOTS              |                  | *TAIL HEAD            | KNOTS                  |                     |                   |  |  |  |
| MET RANGE CORRECTION                                          |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| KNOWN VALUES                                                  | STANDARD VALUES         | VARIATIONS FROM STANDARD | UNIT CORRECTIONS   | PLUS             | MINUS                 |                        |                     |                   |  |  |  |
|                                                               |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| COMPUTATION OF VE                                             |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| PROP TEMP °F                                                  | VE                      | -4.8                     |                    | M/S              |                       | TOTAL RANGE CORRECTION |                     |                   |  |  |  |
| CHANGE TO MV FOR PROP TEMP                                    | M/S                     |                          |                    |                  | MET RANGE CORRECTION  |                        |                     |                   |  |  |  |
| ΔV                                                            | M/S                     |                          | MV UNIT CORRECTION |                  | ΔV RANGE CORRECTION   |                        |                     |                   |  |  |  |
| OLD VE                                                        |                         | + NEW VE                 |                    | =                |                       | +2-AVG VE              |                     | M/S               |  |  |  |
| MET FUZE CORRECTION                                           |                         |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| ΔV                                                            | VARIATION FROM STANDARD | UNIT CORRECTION          | PLUS               | MINUS            |                       |                        |                     |                   |  |  |  |
| RANGE WIND                                                    | H                       |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| AIR TEMP                                                      | D                       |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| AIR DENSITY                                                   | D                       |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| PROJ WEIGHT                                                   | D                       |                          |                    |                  |                       |                        |                     |                   |  |  |  |
| MET FUZE CORR                                                 |                         |                          |                    |                  | TOTAL FUZE CORRECTION |                        | MET FUZE CORRECTION |                   |  |  |  |
|                                                               |                         |                          |                    |                  | FUZE CORRECTION       |                        | +0.5                |                   |  |  |  |
|                                                               |                         |                          |                    |                  | TOTAL FUZE CORRECTION |                        |                     |                   |  |  |  |
| OLD 12 CORR                                                   |                         | + NEW 12 CORR            |                    | =                |                       | +7-AVG 12 CORR         |                     |                   |  |  |  |
| TARGET NO                                                     |                         | BATTERY                  |                    | DATE/TIME        |                       |                        |                     |                   |  |  |  |

DA FORM 12-1, 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

Figure 6-24. Position constants.

b. Enter known data. Enter as indicated in figure 6-25.

(1) The following data is always known data in a subsequent met if the battery and met station have not moved: charge, chart range, latitude, battery altitude, target altitude, MDP altitude,  $\Delta h$  corrections (table D), height of target above gun, comp range (table B) entry range, direction of fire, crosswind unit correction factor (column 8, table F), drift correction (column 9, table F), rotation corrections (tables H and I),

projectile weight, values for a decrease or increase in muzzle velocity (columns 10 and 11, table F), weight correction (columns 18 or 19, table F), propellant temperature, position VE, position deflection correction, and position fuze correction.

(2) If the battery, the MDP, or both have moved, some of the values listed above may have to be recomputed. In this case, the MDP has moved, so a new  $\Delta h$  must be computed and new  $\Delta h$  corrections (table D) extracted.

| MET DATA CORRECTION SHEET                                     |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
|---------------------------------------------------------------|-------------------------|-----------------|--------------------------|-----------------------|-----------------------------|---------------|-----------------------|------------------|---------------|-------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| BATTERY DATA                                                  |                         |                 |                          |                       |                             | MET MESSAGE   |                       |                  |               |       |  |
| CHARGE                                                        | ADJ DE                  | CHART RG        | LATITUDE                 | TYPE MESSAGE          | OCTANT                      | AREA/UNIT     |                       |                  |               |       |  |
| 468                                                           |                         | 5030            | 30°N                     |                       |                             |               |                       |                  |               |       |  |
| ALT OF BTRY (10m)                                             |                         | 340             |                          | DATE                  | TIME                        | ALT MDP       |                       | PRESSURE         |               |       |  |
| ALT OF MDP                                                    |                         |                 |                          | LINE NO               | WIND DIR                    | WIND SPEED    | AIR TEMP              | AIR DENSITY      |               |       |  |
| BTRY ABOVE MDP (m)                                            |                         |                 |                          | $\Delta h$ CORRECTION |                             | =             |                       | =                |               |       |  |
| ALT OF TARGET (nearest meter)                                 |                         | 389             |                          | CORRECTED VALUES      |                             |               |                       |                  |               |       |  |
| HEIGHT OF BURST ABOVE TARGET                                  |                         | 389             |                          |                       |                             |               |                       |                  |               |       |  |
| ALT OF BURST                                                  |                         | 336             |                          |                       |                             |               |                       |                  |               |       |  |
| ALT OF BTRY (nearest meter)                                   |                         | 336             |                          |                       |                             |               |                       |                  |               |       |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (m)                        |                         | +53 ± +100      |                          | COMP RG               | +27                         | CHART RG      | 5030                  | ENTRY RG         | 5057          | 25100 |  |
| WIND COMPONENTS AND DEFLECTION                                |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |                         |                 |                          | 600                   |                             |               |                       |                  |               |       |  |
| DIRECTION OF WIND                                             |                         |                 |                          | TOT = MET + POS + R12 |                             |               |                       |                  |               |       |  |
| (651)                                                         |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| DIRECTION OF FIRE                                             |                         |                 |                          | 700                   |                             |               |                       |                  |               |       |  |
| CHART DIRECTION OF WIND                                       |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| CROSS WIND                                                    | WIND SPEED              | + COMP          | L                        | R                     | KNOTS                       | 0.17          | CROSS WIND L CORR     | 0.6              | ROTATION CORR | 0.6   |  |
| CROSS WIND                                                    | WIND SPEED              | + COMP          | L                        | R                     | KNOTS                       | 0.17          | CROSS WIND R CORR     | 0.6              | ROTATION CORR | 0.6   |  |
| MET RANGE CORRECTION                                          |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
|                                                               | KNOWN VALUES            | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS      | PLUS                        | MINUS         |                       |                  |               |       |  |
| RANGE WIND                                                    | H                       | 0               | H                        |                       |                             |               |                       |                  |               |       |  |
| AIR TEMP                                                      |                         | 100%            | 0                        |                       |                             |               |                       |                  |               |       |  |
| AIR DENSITY                                                   |                         | 100%            | 0                        |                       |                             |               |                       |                  |               |       |  |
| PROJ WEIGHT                                                   | 30                      | 40              | 0.10                     | -35                   |                             | 35            |                       |                  |               |       |  |
| ROTATION                                                      |                         | -17             | X .87                    |                       |                             |               |                       |                  |               |       |  |
| MET RANGE CORR                                                |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| COMPUTATION OF VE                                             |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| PROP +65                                                      | VE                      | -4.8            | M/S                      | D + 28.0              | TOTAL RANGE CORRECTION      |               |                       |                  |               |       |  |
| CHANGE TO MV FOR PROP TEMP                                    |                         |                 | M/S                      | I - 21.6              | MET RANGE CORRECTION        |               |                       |                  |               |       |  |
| $\Delta V$                                                    |                         |                 | M/S                      |                       | $\Delta V$ RANGE CORRECTION |               |                       |                  |               |       |  |
| OLD VE                                                        |                         |                 |                          |                       |                             | + NEW VE      | =                     | +2 = AVG VE      | M/S           |       |  |
| MET FUZE CORRECTION                                           |                         |                 |                          |                       |                             |               |                       |                  |               |       |  |
| $\Delta V$                                                    | VARIATION FROM STANDARD | UNIT CORRECTION | PLUS                     | MINUS                 |                             |               |                       |                  |               |       |  |
| RANGE WIND                                                    | H                       |                 |                          |                       |                             |               |                       |                  |               |       |  |
| AIR TEMP                                                      | D                       |                 |                          |                       |                             |               |                       |                  |               |       |  |
| AIR DENSITY                                                   | D                       |                 |                          |                       |                             |               |                       |                  |               |       |  |
| PROJ WEIGHT                                                   | 0.10                    |                 |                          |                       |                             |               |                       |                  |               |       |  |
| MET FUZE CORR                                                 |                         |                 |                          |                       |                             |               | TOTAL FUZE CORRECTION |                  |               |       |  |
| OLD FZ CORR                                                   |                         |                 |                          |                       |                             | + NEW FZ CORR | =                     | +2 = AVG FZ CORR |               |       |  |
| TARGET NO                                                     |                         |                 |                          |                       |                             | BATTERY       | DATE/TIME             |                  |               |       |  |

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Figure 6-25. Known data.



c. Enter met line number and met message data. Since an adjusted quadrant is unknown, the met line number from the concurrent met is used. The data is recorded as shown in figure 6-26.

| MET DATA CORRECTION SHEET                                     |        |            |          |                  |             |            |          |             |             |
|---------------------------------------------------------------|--------|------------|----------|------------------|-------------|------------|----------|-------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |        |            |          |                  |             |            |          |             |             |
| BATTERY DATA                                                  |        |            |          |                  | MET MESSAGE |            |          |             |             |
| CHARGE                                                        | ADJ QE | CHART RG   | LATITUDE | TYPE MESSAGE     | OCTANT      | AREA/UNIT  |          |             |             |
| 468                                                           |        | 5030       | 30°N     | MET B 3          | 1           | 342988     |          |             |             |
| ALT OF BTRY (10m)                                             |        | 340        |          | DATE             | TIME        | ALT MDP    | PRESSURE |             |             |
|                                                               |        |            |          | 27               | 1430        | 290        | 108.8    |             |             |
| ALT OF MDP                                                    |        |            |          | LINE NO          | WIND DIR    | WIND SPEED | AIR TEMP | AIR DENSITY |             |
|                                                               |        |            |          | 02               | 2600        | 21         | 94.2     | 105.2       |             |
| BTRY ABOVE MDP (Δh)                                           |        |            |          | Δh CORRECTION    |             |            | ±        | ±           |             |
| ALT OF TARGET (nearest meter)                                 |        | 389        |          | CORRECTED VALUES |             |            |          |             |             |
| HEIGHT OF BURST ABOVE TARGET                                  |        |            |          |                  |             |            |          |             |             |
| ALT OF BURST                                                  |        | 389        |          |                  |             |            |          |             |             |
| ALT OF BTRY (nearest meter)                                   |        | 336        |          |                  |             |            |          |             |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |        | +53 ≈ +100 |          | COMP RG          | +27         | CHART RG   | 5030     | ENTRY RG    | 5057 ≈ 5100 |

Figure 6-26. Met message data.

d. Compute  $\Delta h$  and height of target above gun. Since the met station has moved and its altitude changed,  $\Delta h$  must be computed. The height of target above gun (VI) has not changed (fig 6-27).

| MET DATA CORRECTION SHEET                                     |            |            |          |                  |             |            |           |                 |             |
|---------------------------------------------------------------|------------|------------|----------|------------------|-------------|------------|-----------|-----------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |            |            |          |                  |             |            |           |                 |             |
| BATTERY DATA                                                  |            |            |          |                  | MET MESSAGE |            |           |                 |             |
| CHARGE                                                        | ADJ QE     | CHART RG   | LATITUDE | TYPE MESSAGE     | OCTANT      | AREA/UNIT  |           |                 |             |
| 468                                                           |            | 5030       | 30°N     | MET B 3          | 1           | 342988     |           |                 |             |
| ALT OF BTRY (10m)                                             |            | 340        |          | DATE             | TIME        | ALT MDP    | PRESSURE  |                 |             |
|                                                               |            |            |          | 27               | 1430        | 290        | 108.8     |                 |             |
| ALT OF MDP                                                    |            | 290        |          | LINE NO          | WIND DIR    | WIND SPEED | AIR TEMP  | AIR DENSITY     |             |
|                                                               |            |            |          | 02               | 2600        | 21         | 94.2      | 105.2           |             |
| BTRY ABOVE MDP (Δh)                                           |            | +50        |          | Δh CORRECTION    |             |            | ±         | ±               |             |
| ALT OF TARGET (nearest meter)                                 |            | 389        |          | CORRECTED VALUES |             |            |           |                 |             |
| HEIGHT OF BURST ABOVE TARGET                                  |            |            |          |                  |             |            |           |                 |             |
| ALT OF BURST                                                  |            | 389        |          |                  |             |            |           |                 |             |
| ALT OF BTRY (nearest meter)                                   |            | 336        |          |                  |             |            |           |                 |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |            | +53 ≈ +100 |          | COMP RG          | +27         | CHART RG   | 5030      | ENTRY RG        | 5057 ≈ 5100 |
| WIND COMPONENTS AND DEFLECTION                                |            |            |          |                  |             |            |           |                 |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |            | 6400       |          | TOT = MET + POS  |             |            |           |                 |             |
| DIRECTION OF WIND                                             |            |            |          | + R/2            |             |            |           |                 |             |
| (651)                                                         |            |            |          |                  |             |            |           |                 |             |
| DIRECTION OF FIRE                                             |            | 700        |          |                  |             |            |           |                 |             |
| CHART DIRECTION OF WIND                                       |            |            |          |                  |             |            |           |                 |             |
| CROSS WIND                                                    | WIND SPEED | L          | COMP R   | = R              | KNOTS       | 0.17       | UNIT CORR | ROTATION CORR   | 90.6        |
| RANGE WIND                                                    | WIND SPEED | T          | COMP H   | = YAIL HEAD      | KNOTS       |            |           | DRAFT CORR      | 06.3        |
|                                                               |            |            |          |                  |             |            |           | CROSS WIND CORR | R           |
|                                                               |            |            |          |                  |             |            |           | MET DEFL CORR   | R           |
| MET RANGE CORRECTION                                          |            |            |          |                  |             |            |           |                 |             |

Figure 6-27. Height of target above gun.

e. Compute chart direction of wind. Chart direction of the wind is computed as shown in figure 6-28.

| MET DATA CORRECTION SHEET                                     |            |                  |          |                       |             |                   |                |               |         |             |       |           |         |
|---------------------------------------------------------------|------------|------------------|----------|-----------------------|-------------|-------------------|----------------|---------------|---------|-------------|-------|-----------|---------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |            |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| BATTERY DATA                                                  |            |                  |          |                       | MET MESSAGE |                   |                |               |         |             |       |           |         |
| CHARGE                                                        | 468        | ADJ OE           |          | CHART RG              | 5030        | LATITUDE          | 30°N           | TYPE MESSAGE  | MET 8.3 | OCTANT      | 1     | AREA/UNIT | 342.988 |
| ALT OF BTRY (10m)                                             | 340        | DATE             | 27       | TIME                  | 1430        | ALT MDP           | 290            | PRESSURE      | 108.8   |             |       |           |         |
| ALT OF MDP                                                    | 290        | LINE NO.         | 02       | WIND DIR              | 2600        | WIND SPEED        | 21             | AIR TEMP      | 94.2    | AIR DENSITY | 105.2 |           |         |
| BTRY ABOVE MDP (Δh)                                           | +50        | Δh CORRECTION    |          |                       |             |                   |                |               |         |             |       |           |         |
| ALT OF TARGET (nearest meter)                                 | 389        | CORRECTED VALUES |          |                       |             |                   |                |               |         |             |       |           |         |
| HEIGHT OF BURST ABOVE TARGET                                  |            |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| ALT OF BURST                                                  | 389        |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| ALT OF BTRY (nearest meter)                                   | 336        |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        | +53 ≈ +100 | COMP RG          | +27      | CHART RG              | 5030        | ENTRY RG          | 5057 ≈ 5100    |               |         |             |       |           |         |
| WIND COMPONENTS AND DEFLECTION                                |            |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |            | 6400             |          | TOT = MET + POS + R12 |             |                   |                |               |         |             |       |           |         |
| DIRECTION OF WIND                                             |            | 2600             |          |                       |             |                   |                |               |         |             |       |           |         |
| (651)                                                         |            |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| DIRECTION OF FIRE                                             |            | 700              |          |                       |             |                   |                |               |         |             |       |           |         |
| CHART DIRECTION OF WIND                                       |            | 1900             |          |                       |             |                   |                |               |         |             |       |           |         |
| CROSS WIND                                                    | WIND SPEED | 21               | * COMP R | KNOTS = 0.17          |             | CROSS WIND L CORR | R              | ROTATION CORR | 0.6     | DRIFT CORR  | 06.3  |           |         |
| RANGE WIND                                                    | WIND SPEED | 21               | * COMP H | TAIL HEAD             |             | KNOTS             | WIND DEFL CORR | L             | R       |             |       |           |         |
| MET RANGE CORRECTION                                          |            |                  |          |                       |             |                   |                |               |         |             |       |           |         |
| KNOWN                                                         |            | STANDARD         |          | VARIATIONS FROM       |             | UNIT              |                | PIKE          |         | MINUTE      |       |           |         |

Figure 6-28. Chart direction of wind.

f. Enter tables and determine:

- (1) Table B. Same as concurrent met.
- (2) Table C. The data is extracted as shown and recorded as shown in figure 6-29.

| MET DATA CORRECTION SHEET                                     |            |                  |          |                       |             |              |                   |                |               |             |            |           |         |
|---------------------------------------------------------------|------------|------------------|----------|-----------------------|-------------|--------------|-------------------|----------------|---------------|-------------|------------|-----------|---------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |            |                  |          |                       |             |              |                   |                |               |             |            |           |         |
| BATTERY DATA                                                  |            |                  |          |                       | MET MESSAGE |              |                   |                |               |             |            |           |         |
| CHARGE                                                        | 468        | ADJ OE           |          | CHART RG              | 5030        | LATITUDE     | 30°N              | TYPE MESSAGE   | MET 8.3       | OCTANT      | 1          | AREA/UNIT | 342.988 |
| ALT OF BTRY (10m)                                             | 340        | DATE             | 27       | TIME                  | 1430        | ALT MDP      | 290               | PRESSURE       | 108.8         |             |            |           |         |
| ALT OF MDP                                                    | 290        | LINE NO.         | 02       | WIND DIR              | 2600        | WIND SPEED   | 21                | AIR TEMP       | 94.2          | AIR DENSITY | 105.2      |           |         |
| BTRY ABOVE MDP (Δh)                                           | +50        | Δh CORRECTION    |          |                       |             |              |                   |                |               |             |            |           |         |
| ALT OF TARGET (nearest meter)                                 | 389        | CORRECTED VALUES |          |                       |             |              |                   |                |               |             |            |           |         |
| HEIGHT OF BURST ABOVE TARGET                                  |            |                  |          |                       |             |              |                   |                |               |             |            |           |         |
| ALT OF BURST                                                  | 389        |                  |          |                       |             |              |                   |                |               |             |            |           |         |
| ALT OF BTRY (nearest meter)                                   | 336        |                  |          |                       |             |              |                   |                |               |             |            |           |         |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        | +53 ≈ +100 | COMP RG          | +27      | CHART RG              | 5030        | ENTRY RG     | 5057 ≈ 5100       |                |               |             |            |           |         |
| WIND COMPONENTS AND DEFLECTION                                |            |                  |          |                       |             |              |                   |                |               |             |            |           |         |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |            | 6400             |          | TOT = MET + POS + R12 |             |              |                   |                |               |             |            |           |         |
| DIRECTION OF WIND                                             |            | 2600             |          |                       |             |              |                   |                |               |             |            |           |         |
| (651)                                                         |            |                  |          |                       |             |              |                   |                |               |             |            |           |         |
| DIRECTION OF FIRE                                             |            | 700              |          |                       |             |              |                   |                |               |             |            |           |         |
| CHART DIRECTION OF WIND                                       |            | 1900             |          |                       |             |              |                   |                |               |             |            |           |         |
| CROSS WIND                                                    | WIND SPEED | 21               | * COMP R | 96                    | 20          | KNOTS = 0.17 | CROSS WIND L CORR | R              | ROTATION CORR | 0.6         | DRIFT CORR | 06.3      |         |
| RANGE WIND                                                    | WIND SPEED | 21               | * COMP H | 29                    | 6           | TAIL HEAD    | KNOTS             | WIND DEFL CORR | L             | R           |            |           |         |
| MET RANGE CORRECTION                                          |            |                  |          |                       |             |              |                   |                |               |             |            |           |         |

Figure 6-29. Complementary range and wind components.

(3) Table D. The table is entered as shown and the corrections entered as shown in figure 6-30.

FT 155-AM-1

TABLE D

PROJ, HE, M107  
FUZE, PD, M557

## TEMPERATURE AND DENSITY CORRECTIONS

CORRECTIONS TO TEMPERATURE (DT) AND DENSITY (DD), IN PER  
CENT, TO COMPENSATE FOR THE DIFFERENCE IN ALTITUDE,  
IN METERS, BETWEEN THE BATTERY AND THE MDP

| DM    |    | 0     | +10-  | +20-  | +30-  | +40-  | +50-  | +60-  | +70-  |
|-------|----|-------|-------|-------|-------|-------|-------|-------|-------|
| 0     | DT | 0.0   | 0.0   | 0.0   | -0.1+ | -0.1+ | -0.1+ | -0.1+ | -0.2+ |
|       | DD | 0.0   | -0.1+ | -0.2+ | -0.3+ | -0.4+ | -0.5+ | -0.6+ | -0.7+ |
| +100- | DT | -0.2+ | -0.2+ | -0.2+ | -0.3+ | -0.3+ | -0.3+ | -0.3+ | -0.4+ |
|       | DD | -1.0+ | -1.1+ | -1.2+ | -1.3+ | -1.4+ | -1.5+ | -1.6+ | -1.7+ |
| +200- | DT | -0.5+ | -0.5+ | -0.5+ | -0.6+ | -0.6+ | -0.6+ | -0.6+ | -0.7+ |
|       | DD | -2.0+ | -2.1+ | -2.2+ | -2.3+ | -2.4+ | -2.5+ | -2.6+ | -2.7+ |
| +300- | DT | -0.7+ | -0.7+ | -0.7+ | -0.8+ | -0.8+ | -0.8+ | -0.8+ | -0.9+ |
|       | DD | -3.0+ | -3.1+ | -3.2+ | -3.3+ | -3.4+ | -3.5+ | -3.6+ | -3.7+ |

- NOTES - 1. DM IS BATTERY HEIGHT ABOVE OR BELOW THE MDP.  
2. IF ABOVE THE MDP, USE THE SIGN BEFORE THE NUMBER.  
3. IF BELOW THE MDP, USE THE SIGN AFTER THE NUMBER.

| MET DATA CORRECTION SHEET                                     |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
|---------------------------------------------------------------|-----|-----------------|--|--------------------------|-------------|------------------|------|--------------|---------|------------|-------------|-----------|--------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| BATTERY DATA                                                  |     |                 |  |                          | MET MESSAGE |                  |      |              |         |            |             |           |        |
| CHARGE                                                        | 468 | ADJ DE          |  | CHART RG                 | 5030        | LATITUDE         | 30°N | TYPE MESSAGE | MET B 3 | OCTANT     | 1           | AREA/UNIT | 342980 |
| ALT OF BTRY (10m)                                             |     |                 |  |                          | 340         | DATE             | 27   | TIME         | 1430    | ALT MDP    | 290         | PRESSURE  | 108.8  |
| ALT OF MDP                                                    |     |                 |  |                          | 290         | LINE NO          | 02   | WIND DIR     | 2600    | WIND SPEED | 21          | AIR TEMP  | 94.2   |
| BTRY ABOVE MDP (Δh)                                           |     |                 |  |                          | +50         | Δh CORRECTION    |      |              |         | 0.1        | 0.5         |           |        |
| ALT OF TARGET (nearest meter)                                 |     |                 |  |                          | 389         | CORRECTED VALUES |      |              |         |            |             |           |        |
| HEIGHT OF BURST ABOVE TARGET                                  |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| ALT OF BURST                                                  |     |                 |  |                          | 389         |                  |      |              |         |            |             |           |        |
| ALT OF BTRY (nearest meter)                                   |     |                 |  |                          | 336         |                  |      |              |         |            |             |           |        |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |     |                 |  |                          | +53 ≈ +100  | COMP RG          | +27  | CHART RG     | 5030    | ENTRY RG   | 5057 ≈ 5100 |           |        |
| WIND COMPONENTS AND DEFLECTION                                |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |     |                 |  |                          | 6400        |                  |      |              |         |            |             |           |        |
| DIRECTION OF WIND                                             |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| DIRECTION OF FIRE                                             |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| CHART DIRECTION OF WIND                                       |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| CROSS WIND                                                    |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| WIND SPEED                                                    |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| RANGE WIND                                                    |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| WIND SPEED                                                    |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| MET RANGE CORRECTION                                          |     |                 |  |                          |             |                  |      |              |         |            |             |           |        |
| KNOWN VALUES                                                  |     | STANDARD VALUES |  | VARIATIONS FROM STANDARD |             | UNIT CORRECTIONS |      | PLUS         |         | MINUS      |             |           |        |

Figure 6-30. Temperature and density corrections.

| TEMPERATURE OF<br>PROPELLANT<br>DEGREES F | EFFECT<br>ON<br>VELOCITY<br>M/S | TEMPERATURE<br>OF<br>PROPELLANT<br>DEGREES |
|-------------------------------------------|---------------------------------|--------------------------------------------|
| -40                                       | -8.5                            | -40.0                                      |
| -30                                       | -5.7                            | -34.4                                      |
| -20                                       | -5.2                            | -28.9                                      |
| -10                                       | -4.6                            | -23.3                                      |
| 0                                         | -4.0                            | -17.8                                      |
| 10                                        | -3.4                            | -12.2                                      |
| 20                                        | -2.9                            | -6.7                                       |
| 30                                        | -2.3                            | -1.1                                       |
| 40                                        | -1.7                            | 4.4                                        |
| 50                                        | -1.1                            | 10.0                                       |
| 60                                        | -0.6                            | 15.6                                       |
| 70                                        | 0.0                             | 21.1                                       |
| 80                                        | 0.6                             | 26.7                                       |
| 90                                        | 1.1                             | 32.2                                       |
| 100                                       | 1.7                             | 37.8                                       |
| 110                                       | 2.3                             | 43.3                                       |
| 120                                       | 2.9                             | 48.9                                       |
| 130                                       | 3.4                             | 54.4                                       |

|     | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    |
|-----|------|------|------|------|------|------|------|------|------|------|
| 40  | -6.3 |      |      |      |      |      |      |      |      |      |
| 30  | -5.7 | -5.8 | -5.8 | -5.9 | -5.9 | -6.0 | -6.1 | -6.1 | -6.2 | -6.2 |
| 20  | -5.2 | -5.3 | -5.3 | -5.3 | -5.4 | -5.5 | -5.5 | -5.5 | -5.6 | -5.6 |
| 10  | -4.6 | -4.7 | -4.7 | -4.8 | -4.8 | -4.9 | -5.0 | -5.0 | -5.1 | -5.1 |
| 0   | -4.0 | -4.1 | -4.1 | -4.2 | -4.2 | -4.3 | -4.4 | -4.4 | -4.5 | -4.5 |
| 0   | -4.0 | -3.9 | -3.9 | -3.8 | -3.8 | -3.7 | -3.8 | -3.8 | -3.5 | -3.5 |
| 10  | -3.4 | -3.4 | -3.3 | -3.2 | -3.2 | -3.2 | -3.1 | -3.0 | -3.0 | -3.0 |
| 20  | -2.9 | -2.8 | -2.8 | -2.7 | -2.7 | -2.6 | -2.5 | -2.5 | -2.4 | -2.4 |
| 30  | -2.3 | -2.2 | -2.2 | -2.1 | -2.1 | -2.0 | -1.9 | -1.9 | -1.8 | -1.8 |
| 40  | -1.7 | -1.6 | -1.6 | -1.5 | -1.5 | -1.4 | -1.3 | -1.3 | -1.2 | -1.2 |
| 50  | -1.1 | -1.1 | -1.0 | -0.9 | -0.9 | -0.9 | -0.8 | -0.7 | -0.7 | -0.7 |
| 60  | -0.6 | -0.5 | -0.5 | -0.4 | -0.4 | -0.3 | -0.2 | -0.2 | -0.1 | -0.1 |
| 70  | 0.0  | 0.1  | 0.1  | 0.2  | 0.2  | 0.3  | 0.4  | 0.4  | 0.5  | 0.5  |
| 80  | 0.6  | 0.6  | 0.7  | 0.8  | 0.8  | 0.8  | 0.9  | 1.0  | 1.0  | 1.0  |
| 90  | 1.1  | 1.2  | 1.2  | 1.3  | 1.3  | 1.4  | 1.5  | 1.5  | 1.6  | 1.6  |
| 100 | 1.7  | 1.8  | 1.8  | 1.9  | 1.9  | 2.0  | 2.1  | 2.1  | 2.2  | 2.2  |
| 110 | 2.3  | 2.4  | 2.4  | 2.5  | 2.5  | 2.6  | 2.7  | 2.7  | 2.8  | 2.8  |
| 120 | 2.9  | 2.9  | 3.0  | 3.1  | 3.1  | 3.1  | 3.2  | 3.3  | 3.3  | 3.3  |
| 130 | 3.4  |      |      |      |      |      |      |      |      |      |

| MET DATA CORRECTION SHEET                                       |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
|-----------------------------------------------------------------|--------|-------------------------------------------|-------------------------|-------------------------------------------|--------------------|-------------------------------------------|--|-------------------------------------------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC   |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| BATTERY DATA                                                    |        |                                           |                         |                                           | MET MESSAGE        |                                           |  |                                           |  |
| CHARGE<br><b>468</b>                                            | ADJ DE | CHART NO<br><b>5030</b>                   | LATITUDE<br><b>30°N</b> | TYPE MESSAGE<br><b>MET 1.3</b>            | OCTANT<br><b>1</b> | AREA/TIME<br><b>342788</b>                |  |                                           |  |
| ALT OF BTRY (10m)<br><b>340</b>                                 |        | DATE<br><b>27</b>                         |                         | TIME<br><b>1430</b>                       |                    | ALT MDP<br><b>290</b>                     |  | PRESSURE<br><b>108.8</b>                  |  |
| ALT OF MDP<br><b>290</b>                                        |        | LINE NO<br><b>12</b>                      |                         | WIND DIR<br><b>2600</b>                   |                    | WIND SPEED<br><b>21</b>                   |  | AIR TEMP<br><b>94.2</b>                   |  |
| BTRY ABOVE MDP (Ah)<br><b>+50</b>                               |        | AN CORRECTION                             |                         | AIR DENSITY<br><b>0.01</b>                |                    | AIR DENSITY<br><b>0.05</b>                |  |                                           |  |
| ALT OF TARGET (nearest meter)<br><b>389</b>                     |        | CORRECTED VALUES                          |                         |                                           |                    |                                           |  |                                           |  |
| HEIGHT OF BURST ABOVE TARGET<br><b>389</b>                      |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| ALT OF BURST<br><b>336</b>                                      |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| ALT OF BTRY (nearest meter)<br><b>336</b>                       |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)<br><b>+532 ± 100</b>     |        | COMP RG<br><b>+27</b>                     |                         | CHART RG<br><b>5030</b>                   |                    | ENTRY RG<br><b>50574</b>                  |  | <b>5100</b>                               |  |
| WIND COMPONENTS AND DEFLECTION                                  |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| WHEN DIRECTION OF WIND IS LESS THAN OUR FIRE ADD<br><b>6400</b> |        | TOT = MET + POS + R12                     |                         |                                           |                    |                                           |  |                                           |  |
| DIRECTION OF WIND<br><b>(651)</b>                               |        | DIRECTION OF WIND<br><b>2600</b>          |                         |                                           |                    |                                           |  |                                           |  |
| DIRECTION OF FIRE<br><b>700</b>                                 |        | DIRECTION OF FIRE<br><b>700</b>           |                         |                                           |                    |                                           |  |                                           |  |
| CHART DIRECTION OF WIND<br><b>1900</b>                          |        | CHART DIRECTION OF WIND<br><b>1900</b>    |                         |                                           |                    |                                           |  |                                           |  |
| CROSS WIND<br><b>21</b>                                         |        | CROSS WIND<br><b>0.96</b>                 |                         | CROSS WIND<br><b>0.20</b>                 |                    | CROSS WIND<br><b>0.17</b>                 |  | CROSS WIND<br><b>0.63</b>                 |  |
| WIND SPEED<br><b>21</b>                                         |        | WIND SPEED<br><b>0.29</b>                 |                         | WIND SPEED<br><b>0.29</b>                 |                    | WIND SPEED<br><b>0.29</b>                 |  | WIND SPEED<br><b>0.29</b>                 |  |
| MET RANGE CORRECTION                                            |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| KNOWN VALUES                                                    |        | STANDARD VALUES                           |                         | VARIATIONS FROM STANDARD                  |                    | UNIT CORRECTIONS                          |  | PLUS MINUS                                |  |
| RANGE WIND<br><b>17</b>                                         |        | RANGE WIND<br><b>0</b>                    |                         | RANGE WIND<br><b>0</b>                    |                    | RANGE WIND<br><b>0</b>                    |  | RANGE WIND<br><b>0</b>                    |  |
| AIR TEMP<br><b>100%</b>                                         |        | AIR TEMP<br><b>100%</b>                   |                         | AIR TEMP<br><b>100%</b>                   |                    | AIR TEMP<br><b>100%</b>                   |  | AIR TEMP<br><b>100%</b>                   |  |
| AIR DENSITY<br><b>100%</b>                                      |        | AIR DENSITY<br><b>100%</b>                |                         | AIR DENSITY<br><b>100%</b>                |                    | AIR DENSITY<br><b>100%</b>                |  | AIR DENSITY<br><b>100%</b>                |  |
| PROJ WEIGHT<br><b>100%</b>                                      |        | PROJ WEIGHT<br><b>100%</b>                |                         | PROJ WEIGHT<br><b>100%</b>                |                    | PROJ WEIGHT<br><b>100%</b>                |  | PROJ WEIGHT<br><b>100%</b>                |  |
| ROTATION<br><b>-17</b>                                          |        | ROTATION<br><b>-17</b>                    |                         | ROTATION<br><b>-17</b>                    |                    | ROTATION<br><b>-17</b>                    |  | ROTATION<br><b>-17</b>                    |  |
| MET RANGE CORR                                                  |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| COMPUTATION OF VE                                               |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| VE<br><b>+65</b>                                                |        | VE<br><b>-4.8</b>                         |                         | VE<br><b>-4.8</b>                         |                    | VE<br><b>-4.8</b>                         |  | VE<br><b>-4.8</b>                         |  |
| CHANGE TO MP FOR PROP TEMP<br><b>-0.3</b>                       |        | CHANGE TO MP FOR PROP TEMP<br><b>-0.3</b> |                         | CHANGE TO MP FOR PROP TEMP<br><b>-0.3</b> |                    | CHANGE TO MP FOR PROP TEMP<br><b>-0.3</b> |  | CHANGE TO MP FOR PROP TEMP<br><b>-0.3</b> |  |
| ΔV<br><b>-21.6</b>                                              |        | ΔV<br><b>-21.6</b>                        |                         | ΔV<br><b>-21.6</b>                        |                    | ΔV<br><b>-21.6</b>                        |  | ΔV<br><b>-21.6</b>                        |  |
| TOTAL RANGE CORRECTION<br><b>-21.6</b>                          |        | TOTAL RANGE CORRECTION<br><b>-21.6</b>    |                         | TOTAL RANGE CORRECTION<br><b>-21.6</b>    |                    | TOTAL RANGE CORRECTION<br><b>-21.6</b>    |  | TOTAL RANGE CORRECTION<br><b>-21.6</b>    |  |
| OLD VE + NEW VE = +2 = AVG VE M/S                               |        |                                           |                         |                                           |                    |                                           |  |                                           |  |
| MET FUZE CORRECTION                                             |        |                                           |                         |                                           |                    |                                           |  |                                           |  |

6-32



## j. Enter tables.

(1) *Table F.* The values in columns 8 and 9 are the same as the concurrent met. The other values are extracted and recorded as shown in figure 6-34.

(2) *Table H.* Same as concurrent met.

(3) *Table I.* Same as concurrent met.

| MET DATA CORRECTION SHEET                                     |                         |      |                  |       |                |                  |           |                        |             |
|---------------------------------------------------------------|-------------------------|------|------------------|-------|----------------|------------------|-----------|------------------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                         |      |                  |       |                |                  |           |                        |             |
| BATTERY DATA                                                  |                         |      |                  |       |                |                  |           |                        |             |
| CHARGE                                                        | 100                     | 3830 | 360              | MET 3 |                | 1                | 340988    |                        |             |
| ALT OF BTRY (10m)                                             | 340                     |      | DATE             | 27    | TIME           | 1430             | ALT       | 290                    | PRESSURE    |
| ALT OF MDP                                                    | 290                     |      | WIND DIR         | 02    | WIND SPD       | 20               | WIND CORR | 0.17                   | AIR DENSITY |
| BTRY CORR MDP (AN)                                            | +50                     |      | AA CORRECTION    | 0.01  |                | 0.5              |           |                        |             |
| ALT OF TARGET (nearest burst)                                 | 389                     |      | CORRECTED VALUES | 94.1  |                | 104.7            |           |                        |             |
| HEIGHT OF BURST ABOVE TARGET                                  | 389                     |      |                  |       |                |                  |           |                        |             |
| ALT OF BURST                                                  | 336                     |      |                  |       |                |                  |           |                        |             |
| ALT OF BTRY (nearest burst)                                   | 336                     |      |                  |       |                |                  |           |                        |             |
| HEIGHT OF TARGET (burst above gun)                            | +53 ± 100               |      | COMP RC          | +27   |                | CHART RC         | 5030      |                        | ENTRY RC    |
| WIND COMPONENTS AND DEFLECTION                                |                         |      |                  |       |                |                  |           |                        |             |
| WHEN DIRECTION OF WIND IS LESS THAN OUR FIRE ADD              | 9400                    |      | TOT = MET + POS  |       |                |                  |           |                        |             |
| DIRECTION OF WIND                                             | 2600                    |      | + R12            |       |                |                  |           |                        |             |
| DIRECTION OF FIRE                                             | 700                     |      | ROTATION 0.6     |       |                |                  |           |                        |             |
| CHART DIRECTION OF WIND                                       | 1900                    |      | DRY CORR 0.63    |       |                |                  |           |                        |             |
| CROSS WIND                                                    | 21                      |      | COMP             | 0.96  |                | 0.20             | KNOTS     | 0.17                   |             |
| RANGE WIND                                                    | 21                      |      | COMP             | 0.29  |                | 0.06             | KNOTS     | 0.06                   |             |
| MET RANGE CORRECTION                                          |                         |      |                  |       |                |                  |           |                        |             |
| RANGE WIND                                                    | 6                       |      | STANDARD VALUES  | 0     |                | UNIT CORRECTIONS | 2.1       |                        |             |
| AIR TEMP                                                      | 94.1                    |      | 100%             | 0     |                | 5.9              | +12.5     |                        |             |
| AIR DENSITY                                                   | 104.7                   |      | 100%             | 0     |                | 4.7              | +5.9      |                        |             |
| PROJ WEIGHT                                                   | 30                      |      | 40               | 0     |                | 10               | -35       |                        |             |
| ROTATION                                                      | -17                     |      | X                |       | 8.7            |                  |           |                        |             |
| MET RANGE CORR                                                |                         |      |                  |       |                |                  |           |                        |             |
| COMPUTATION OF VE                                             |                         |      |                  |       |                |                  |           |                        |             |
| PROP +65                                                      | VE                      |      | -4.8             |       | M/S            | D + 28.0         |           | TOTAL RANGE CORRECTION |             |
| CHANGE TO MV FOR PROP TEMP                                    | AV                      |      | -0.3             |       | M/S            | I - 21.6         |           | MET RANGE CORRECTION   |             |
|                                                               |                         |      |                  |       |                |                  |           | AV RANGE CORRECTION    |             |
|                                                               |                         |      |                  |       |                |                  |           | TOTAL RANGE CORRECTION |             |
| MET FUZE CORRECTION                                           |                         |      |                  |       |                |                  |           |                        |             |
| AV                                                            | VARIATION FROM STANDARD |      | UNIT CORRECTION  |       | PLUS           |                  | MINUS     |                        |             |
| RANGE WIND                                                    | 0                       |      |                  |       |                |                  |           |                        |             |
| AIR TEMP                                                      | 0                       |      |                  |       |                |                  |           |                        |             |
| AIR DENSITY                                                   | 0                       |      |                  |       |                |                  |           |                        |             |
| PROJ WEIGHT                                                   | 0                       |      |                  |       |                |                  |           |                        |             |
|                                                               |                         |      |                  |       |                |                  |           | TOTAL FUZE CORRECTION  |             |
|                                                               |                         |      |                  |       |                |                  |           | FUZE CORRECTION        |             |
|                                                               |                         |      |                  |       |                |                  |           | TOTAL FUZE CORRECTION  |             |
|                                                               |                         |      |                  |       |                |                  |           | +0.5                   |             |
| MET FUZE CORR                                                 |                         |      |                  |       |                |                  |           |                        |             |
| OLD FZ CORR                                                   | + NEW FZ CORR           |      | =                |       | +2-AVG FZ CORR |                  |           |                        |             |
| TARGET NO.                                                    | BATTERY                 |      | DATE/TIME        |       |                |                  |           |                        |             |

DA FORM 7, 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

U.S. G.P.O. 1977-765037/45

PT 155-AR-1

PROJ, ME, RIOT  
FUZE, PD, MSST

TABLE F  
CORRECTION FACTORS

CHARGE  
4G

| 1                     | 10                    | 11    | 12                | 13   | 14             | 15   | 16                | 17   | 18                          | 19  |
|-----------------------|-----------------------|-------|-------------------|------|----------------|------|-------------------|------|-----------------------------|-----|
| R<br>A<br>N<br>G<br>E | RANGE CORRECTIONS FOR |       |                   |      |                |      |                   |      |                             |     |
|                       | MUZZLE VELOCITY 1 M/S |       | RANGE WIND 1 KNOT |      | AIR TEMP 1 PCT |      | AIR DENSITY 1 PCT |      | PROJ WT OF 1 SQ (14 SQ STD) |     |
|                       | DEC                   | INC   | HEAD              | TAIL | DEC            | INC  | DEC               | INC  | DEC                         | INC |
|                       | R                     | R     | R                 | R    | R              | R    | R                 | R    | R                           | R   |
| 3500                  | 19.8                  | -15.2 | 4.4               | -1.1 | 9.3            | -1.5 | -2.8              | 2.9  | -26                         | 28  |
| 3600                  | 20.3                  | -15.6 | 4.6               | -1.2 | 9.5            | -1.5 | -3.0              | 3.0  | -26                         | 29  |
| 3700                  | 20.8                  | -16.0 | 4.7               | -1.2 | 9.8            | -1.5 | -3.2              | 3.2  | -27                         | 29  |
| 3800                  | 21.4                  | -16.4 | 4.9               | -1.3 | 10.0           | -1.6 | -3.3              | 3.4  | -28                         | 30  |
| 3900                  | 21.9                  | -16.8 | 5.0               | -1.3 | 10.2           | -1.6 | -3.5              | 3.5  | -28                         | 31  |
| 4000                  | 22.4                  | -17.2 | 5.1               | -1.4 | 10.5           | -1.6 | -3.7              | 3.7  | -29                         | 31  |
| 4100                  | 22.9                  | -17.6 | 5.3               | -1.5 | 10.7           | -1.7 | -3.8              | 3.9  | -29                         | 32  |
| 4200                  | 23.4                  | -18.0 | 5.4               | -1.5 | 10.9           | -1.7 | -4.0              | 4.1  | -30                         | 33  |
| 4300                  | 23.9                  | -18.4 | 5.6               | -1.6 | 11.1           | -1.7 | -4.2              | 4.3  | -30                         | 33  |
| 4400                  | 24.4                  | -18.8 | 5.7               | -1.6 | 11.3           | -1.8 | -4.4              | 4.5  | -31                         | 34  |
| 4500                  | 24.9                  | -19.2 | 5.9               | -1.7 | 11.5           | -1.8 | -4.6              | 4.7  | -31                         | 34  |
| 4600                  | 25.4                  | -19.6 | 6.0               | -1.8 | 11.7           | -1.8 | -4.8              | 4.9  | -32                         | 35  |
| 4700                  | 26.0                  | -20.0 | 6.1               | -1.8 | 11.9           | -1.8 | -5.0              | 5.1  | -32                         | 36  |
| 4800                  | 26.5                  | -20.4 | 6.3               | -1.9 | 12.0           | -1.9 | -5.2              | 5.3  | -33                         | 36  |
| 4900                  | 27.0                  | -20.8 | 6.4               | -2.0 | 12.2           | -1.9 | -5.4              | 5.5  | -33                         | 37  |
| 5000                  | 27.5                  | -21.2 | 6.5               | -2.0 | 12.4           | -1.9 | -5.6              | 5.7  | -34                         | 37  |
| 5100                  | 28.0                  | -21.6 | 6.7               | -2.1 | 12.5           | -1.9 | -5.8              | 5.9  | -35                         | 38  |
| 5200                  | 28.5                  | -22.0 | 6.8               | -2.2 | 12.7           | -1.9 | -6.1              | 6.2  | -35                         | 38  |
| 5300                  | 29.0                  | -22.4 | 6.9               | -2.2 | 12.9           | -2.0 | -6.3              | 6.4  | -36                         | 39  |
| 5400                  | 29.4                  | -22.8 | 7.1               | -2.3 | 13.0           | -2.0 | -6.5              | 6.6  | -36                         | 39  |
| 5500                  | 29.9                  | -23.2 | 7.2               | -2.4 | 13.2           | -2.0 | -6.8              | 6.9  | -36                         | 40  |
| 5600                  | 30.4                  | -23.6 | 7.3               | -2.5 | 13.3           | -2.0 | -7.0              | 7.1  | -37                         | 41  |
| 5700                  | 30.9                  | -24.1 | 7.4               | -2.5 | 13.4           | -2.0 | -7.2              | 7.3  | -37                         | 41  |
| 5800                  | 31.4                  | -24.5 | 7.6               | -2.6 | 13.6           | -2.0 | -7.5              | 7.6  | -38                         | 42  |
| 5900                  | 31.9                  | -24.9 | 7.7               | -2.7 | 13.7           | -2.1 | -7.7              | 7.9  | -38                         | 42  |
| 6000                  | 32.4                  | -25.3 | 7.8               | -2.8 | 13.8           | -2.1 | -8.0              | 8.1  | -39                         | 43  |
| 6100                  | 32.9                  | -25.7 | 7.9               | -2.9 | 13.9           | -2.1 | -8.2              | 8.4  | -39                         | 43  |
| 6200                  | 33.4                  | -26.1 | 8.1               | -3.0 | 14.0           | -2.1 | -8.5              | 8.7  | -40                         | 44  |
| 6300                  | 33.8                  | -26.5 | 8.2               | -3.0 | 14.1           | -2.1 | -8.8              | 8.9  | -40                         | 44  |
| 6400                  | 34.3                  | -26.9 | 8.3               | -3.1 | 14.2           | -2.1 | -9.0              | 9.2  | -41                         | 45  |
| 6500                  | 34.8                  | -27.3 | 8.4               | -3.2 | 14.3           | -2.1 | -9.3              | 9.5  | -41                         | 45  |
| 6600                  | 35.3                  | -27.7 | 8.5               | -3.3 | 14.4           | -2.1 | -9.6              | 9.8  | -42                         | 46  |
| 6700                  | 35.8                  | -28.1 | 8.6               | -3.4 | 14.5           | -2.1 | -9.9              | 10.1 | -42                         | 46  |
| 6800                  | 36.3                  | -28.5 | 8.7               | -3.5 | 14.6           | -2.2 | -10.1             | 10.4 | -42                         | 46  |
| 6900                  | 36.7                  | -29.0 | 8.8               | -3.6 | 14.6           | -2.2 | -10.4             | 10.7 | -43                         | 47  |
| 7000                  | 37.2                  | -29.4 | 9.0               | -3.7 | 14.7           | -2.2 | -10.7             | 11.0 | -43                         | 47  |

Figure 6-34. Rotation correction factors.

## k. Compute (fig 6-35).

(1) *Met deflection correction.* This is computed as in the concurrent met and is shown below.

(2) *Total deflection correction.* The new total deflection correction is determined by adding the position deflection correction and the met deflection correction.

| MET DATA CORRECTION SHEET                                     |              |                 |                          |                  |             |            |          |                 |             |
|---------------------------------------------------------------|--------------|-----------------|--------------------------|------------------|-------------|------------|----------|-----------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                 |                          |                  |             |            |          |                 |             |
| BATTERY DATA                                                  |              |                 |                          |                  | MET MESSAGE |            |          |                 |             |
| CHARGE                                                        | ADJ QE       | CHART RG        | LATITUDE                 | TYPE MESSAGE     | OCTANT      | AREA/UNIT  |          |                 |             |
| 466                                                           |              | 5030            | 30°N                     | MET B 3          | 1           | 342988     |          |                 |             |
| ALT OF BTRY (10m)                                             |              | 340             |                          | DATE             | TIME        | ALT MDP    | PRESSURE |                 |             |
|                                                               |              |                 |                          | 27               | 1430        | 290        | 708.8    |                 |             |
| ALT OF MDP                                                    |              | 290             |                          | LINE NO          | WIND DIR    | WIND SPEED | AIR TEMP | AIR DENSITY     |             |
|                                                               |              |                 |                          | 02               | 2600        | 21         | 94.2     | 105.2           |             |
| BTRY ABOVE MDP (Δh)                                           |              | +50             |                          | Δh CORRECTION    |             | 0.1        |          | 0.5             |             |
| ALT OF TARGET (nearest meter)                                 |              | 389             |                          | CORRECTED VALUES |             | 94.1       |          | 104.7           |             |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                 |                          |                  |             |            |          |                 |             |
| ALT OF BURST                                                  |              | 389             |                          |                  |             |            |          |                 |             |
| ALT OF BTRY (nearest meter)                                   |              | 336             |                          |                  |             |            |          |                 |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              | +53 ≈ +100      |                          | COMP RG          | +27         | CHART RG   | 5030     | ENTRY RG        | 5057 ≈ 5100 |
| WIND COMPONENTS AND DEFLECTION                                |              |                 |                          |                  |             |            |          |                 |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              | 6400            |                          | TOT = MET + POS  |             |            |          |                 |             |
| DIRECTION OF WIND                                             |              | 2600            |                          | RB = L4 + R12    |             |            |          |                 |             |
| (651)                                                         |              |                 |                          |                  |             |            |          |                 |             |
| DIRECTION OF FIRE                                             |              | 700             |                          |                  |             |            |          |                 |             |
| CHART DIRECTION OF WIND                                       |              | 1900            |                          |                  |             |            |          |                 |             |
| CROSS WIND                                                    | WIND SPEED   | 21              | * COMP R                 | .96              | R 20        | KNOTS      | 0.17     | CROSS WIND CORR | 0.6         |
| RANGE WIND                                                    | WIND SPEED   | 21              | * COMP R                 | .29              | TAIL        | 6          | KNOTS    | 3.4             | 3.5 ≈ L4    |
| MET RANGE CORRECTION                                          |              |                 |                          |                  |             |            |          |                 |             |
|                                                               | KNOWN VALUES | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS        | MINUS      |          |                 |             |
| RANGE WIND                                                    | 6            | 0               | 6                        | -2.1             |             | 12.6       |          |                 |             |

Figure 6-35. Met deflection correction and total deflection correction.

## l. Compute (fig 6-36).

(1) *Met range correction.* The met range correction is computed as shown below.

(2) *Total range correction.* The  $\Delta V$  range correction is determined, then added to the met range correction to determine a new total range correction. First, the  $\Delta V$  is determined by adding the position VE and the change to muzzle velocity for propellant temperature. The  $\Delta V$  is converted to a  $\Delta V$  range correction by multiplying it by the appropriate MV unit correction factor. If  $\Delta V$  is minus, the decrease factor is used; if  $\Delta V$  is plus, the increase factor is used. The  $\Delta V$  range correction is then added to the met range correction. The total range correction is expressed to the nearest 10 meters.

(3) *Adjusted elevation.* The total range correction is added to the chart range. The GFT MHL is set over this range to determine an adjusted elevation.

|                                   |                            |                 |                          |                          |                        |       |                 |      |
|-----------------------------------|----------------------------|-----------------|--------------------------|--------------------------|------------------------|-------|-----------------|------|
| CROSS WIND SPEED                  | 21                         | + CORR          | 0.96                     | 0.20                     | KNOTS                  | 0.17  | CORR            | 06.3 |
| RANGE WIND SPEED                  | 21                         | + CORR          | 0.29                     | 0.06                     | KNOTS                  | 0.06  | CROSS WIND CORR | 03.4 |
| MET RANGE CORRECTION              |                            |                 |                          |                          |                        |       |                 | 03.6 |
|                                   | KNOWN VALUES               | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS         | PLUS                   | MINUS |                 |      |
| RANGE WIND                        | 6                          | 0               | 6                        | -2.1                     |                        | 12.6  |                 |      |
| AIR TEMP                          | 94.1                       | 100%            | 5.9                      | +12.5                    | 73.8                   |       |                 |      |
| AIR DENSITY                       | 104.7                      | 100%            | 4.7                      | +5.9                     | 27.7                   |       |                 |      |
| PROJ WEIGHT                       | 30                         | 40              | 10                       | -35                      |                        | 35.0  |                 |      |
| ROTATION                          |                            |                 | -17                      | x .87                    |                        | 14.8  |                 |      |
|                                   |                            |                 |                          |                          |                        | 101.5 | 62.4            |      |
|                                   |                            |                 |                          |                          |                        | 62.4  |                 |      |
| MET RANGE CORR                    |                            |                 |                          |                          |                        | 39.1  |                 | +39  |
| COMPUTATION OF VE                 |                            |                 |                          |                          |                        |       |                 |      |
| PROP TEMP +65                     | VE                         | -4.8            | M/S                      | D+28.0                   | TOTAL RANGE CORRECTION |       |                 |      |
|                                   | CHANGE TO MV FOR PROP TEMP | -0.3            | M/S                      | I-21.6                   | MET RANGE CORRECTION   | +39   |                 |      |
|                                   | ΔV                         | -5.1            | M/S                      | MV UNIT CORRECTION +28.0 | ΔV RANGE CORRECTION    | +143  |                 |      |
|                                   |                            |                 |                          |                          | TOTAL RANGE CORRECTION | +182  | ≈ +180          |      |
| OLD VE + NEW VE = +2 = AVG VE M/S |                            |                 |                          |                          |                        |       |                 |      |
| MET FUZE CORRECTION               |                            |                 |                          |                          |                        |       |                 |      |

Figure 6-36. Met range correction and total range correction.

m. *Enter variations and determine values from table J (fig 6-37).* The variations from standard are entered in the Met Fuze Correction block and the appropriate values are extracted from table J. The entry argument for table J is the fuze setting corresponding to the adjusted elevation.

|                                              |                            |                 |      |                          |                        |                |
|----------------------------------------------|----------------------------|-----------------|------|--------------------------|------------------------|----------------|
| MET RANGE CORR                               |                            |                 |      |                          | 39.1                   | +39            |
| COMPUTATION OF VE                            |                            |                 |      |                          |                        |                |
| PROP TEMP +65                                | VE                         | -4.8            | M/S  | D+28.0                   | TOTAL RANGE CORRECTION |                |
|                                              | CHANGE TO MV FOR PROP TEMP | -0.3            | M/S  | I-21.6                   | MET RANGE CORRECTION   | +39            |
|                                              | ΔV                         | -5.1            | M/S  | MV UNIT CORRECTION +28.0 | ΔV RANGE CORRECTION    | +143           |
|                                              |                            |                 |      |                          | TOTAL RANGE CORRECTION | +182 ≈ +180    |
| OLD VE + NEW VE = +2 = AVG VE M/S            |                            |                 |      |                          |                        |                |
| FS ~ EL 311 = 18.7 ≈ 19 MET FUZE CORRECTION  |                            |                 |      |                          |                        |                |
| ΔV                                           | VARIATION FROM STANDARD    | UNIT CORRECTION | PLUS | MINUS                    |                        |                |
| 5.1                                          |                            | -.054           |      | .275                     | +180                   | 5210           |
| RANGE WIND                                   | 6                          | +.002           | .012 |                          | 5030                   | EL 311 T: 18.8 |
| AIR TEMP                                     | 5.9                        | -.023           |      | .136                     |                        | 18.7 +0.1      |
| AIR DENSITY                                  | 4.7                        | -.006           |      | .028                     |                        |                |
| PROJ WEIGHT                                  | 10                         | +.077           | .077 |                          |                        |                |
|                                              |                            |                 |      |                          | TOTAL FUZE CORRECTION  |                |
|                                              |                            |                 |      |                          | .089                   | .439           |
|                                              |                            |                 |      |                          | .089                   |                |
|                                              |                            |                 |      |                          | .350                   |                |
| MET FUZE CORR                                |                            |                 |      |                          |                        |                |
|                                              |                            |                 |      |                          |                        | -0.4           |
|                                              |                            |                 |      |                          |                        | +0.5           |
|                                              |                            |                 |      |                          |                        | +0.1           |
| OLD FZ CORR + NEW FZ CORR = +2 = AVG FZ CORR |                            |                 |      |                          |                        |                |
| TARGET NO.                                   | REG PT 2                   | BATTERY         | A    | DATE/TIME                | 28 Jun 1030            |                |

DA FORM 74200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

\* U.S. G.P.O. 1977-765037/45

Figure 6-37. Fuze correction computations.



*n. Compute met fuze correction and total fuze correction.* The met fuze correction is determined as in the concurrent met (fig 6-37). The met fuze correction is added to the position fuze correction to determine a total fuze correction.

*o. Determine GFT setting.* The new GFT setting is the same as the old one except for a new adjusted time and elevation. The GFT

deflection correction is found by subtracting drift corresponding to the new adjusted elevation from the new total deflection correction.

GFT A: Chg 4, Lot XY, Rg 5030, El 311, Ti 18.8  
Tot df corr R8  
Drift ~el 311 = L7  
GFT df corr R15

## Section V. SUBSEQUENT MET APPLICATIONS

### 6-13. Eight-Direction Met

Current doctrine requires a firing unit to provide accurate artillery support throughout a 6400-mil zone. Traditional transfer limits define an area within which registration corrections are assumed to be valid. These transfer limits place a severe limitation on a 6400-mil firing capability. Registration corrections could be obtained by conducting a registration in each 800-mil sector of the unit's area of responsibility, but at a tremendous cost in ammunition. FADAC provides corrected firing data throughout 6400 mils and can provide data for use in determining a GFT setting and GFT deflection correction for each 800-mil segment of a unit's area of responsibility. However, when FADAC is not available, a manual solution of determining corrections throughout 6400 mils must be used. The graphical application of current registration or met + VE corrections produces accurate results within certain limits—the range and deflection transfer limits. The deflection transfer limits can be eliminated by determining a registration or MET + VE GFT setting and GFT deflection correction for each 800-mil sector of the unit's area of responsibility.

*a.* The eight-direction met procedure provides corrections to range, deflection, and fuze setting to compensate for the effects of ballistic wind direction and velocity and for rotation of the Earth throughout the firing unit's area of responsibility. When these

corrections are combined with known position corrections, lateral transfer limits can be eliminated for ranges 10,000 meters or less. For ranges greater than 10,000 meters, because the lateral transfer limits are valid 4000 meters right and 4000 meters left of the battery registration point line, there will be areas between the 800-mil segments that are not covered by valid corrections. When needed, additional GFT settings must be computed to cover these areas. The eight-direction met technique consists of two steps:

(1) Solution of a met message concurrent with a registration to determine the position VE, position deflection correction, and position fuze correction. (Average position corrections will be computed when possible.)

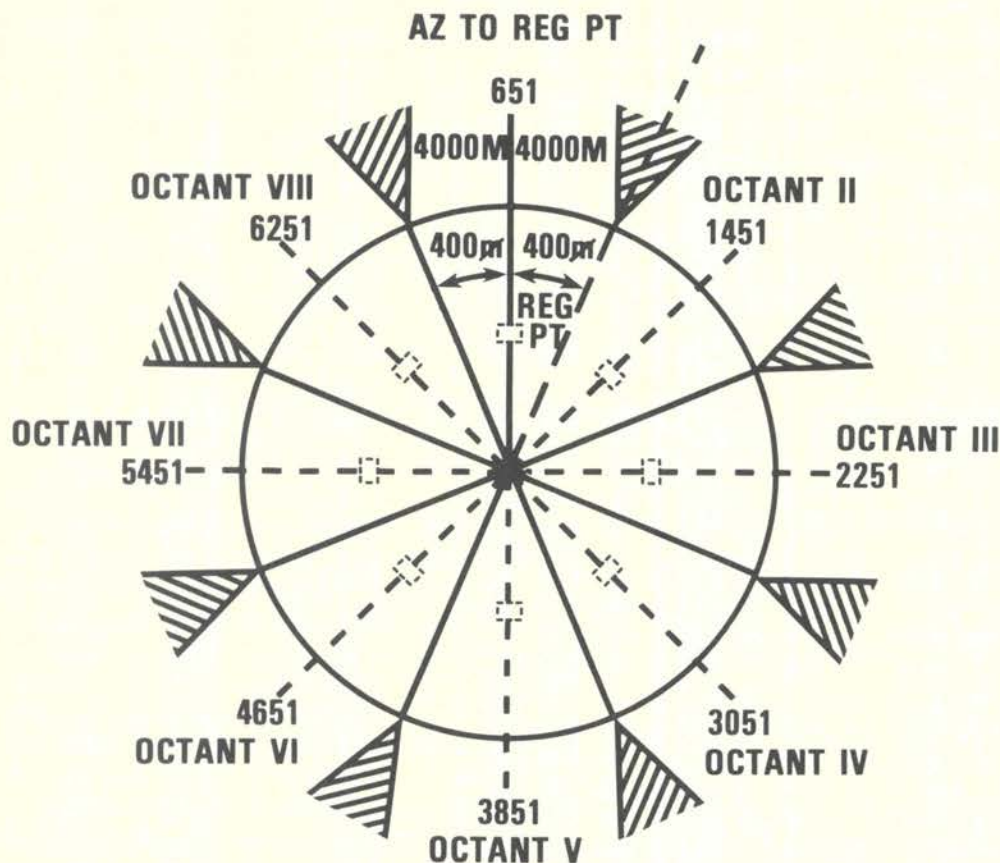
(2) Solution of a met message for other 800-mil segments using met + VE technique and the position VE, position deflection correction, and position fuze correction to determine GFT settings for those octants.

*Note.* The major change is the direction of fire for each octant and its effect on wind and rotation corrections.

*b.* Using the data from paragraph 6-12, the FDO decides to determine a GFT setting for octant II, 800 mils to the right (fig 6-38).

(1) All shaded blocks indicate data that is known or unchanged from the subsequent met.

(2) Target altitude is the same as the registration point.



(3) Met line number is the same as the subsequent met.

(4) In this example, fuze setting corresponding to new adjusted elevation yields the same entry argument for table J. This entry argument *may* change.

(5) GFT setting for octant II is:

GFT A: Chg 4, Lot XY, Rg 5030, El 316, Ti 19.0

★ (6)  $GFT\ df\ corr = total - drift$   
 $R15 = R8 - L7$

#### ★ 6-14. Met to a Met Checkpoint

a. When data from two registrations, two met + VE computations, or a combination thereof are known, a more accurate GFT setting can be achieved by constructing a GFT setting from two or more plot points. When a GFT setting is constructed with two

plot points, it may be used for the full range of the GFT without regard to range transfer limits. Solution of the met to the met checkpoint will yield a total range correction, a total deflection correction, and a total fuze correction at the met checkpoint range. The met checkpoint selected will be the farthest away (in range) from the registration point range. If a two-plot GFT setting is to be constructed, it is preferable to register in either the upper or lower third of the GFT range and then solve a met to an opposite met checkpoint. The result will actually yield two GFT settings.

b. Using the data from the previous problem (para 6-13), the FDO decides to determine a two-plot GFT setting to octant II using range 3790 (fig 6-39).

(1) All shaded blocks indicate data that

## 8 DIRECTION MET (OCTANT II)

| MET DATA CORRECTION SHEET                                     |                         |                            |                          |                  |                          |                        |             |             |             |
|---------------------------------------------------------------|-------------------------|----------------------------|--------------------------|------------------|--------------------------|------------------------|-------------|-------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                         |                            |                          |                  |                          |                        |             |             |             |
| BATTERY DATA                                                  |                         |                            |                          |                  | MET MESSAGE              |                        |             |             |             |
| CHARGE                                                        | ADJ OE                  | CHART RG                   | LATITUDE                 | TYPE MESSAGE     | OCTANT                   | AREA/UNIT              |             |             |             |
| 488                                                           |                         | 5030                       | 30°N                     | MET 83           | 1                        | 342988                 |             |             |             |
| ALT OF BTRY (10m)                                             |                         | 340                        |                          | DATE             | TIME                     | ALT MDP                | PRESSURE    |             |             |
|                                                               |                         |                            |                          | 27               | 1430                     | 290                    | 108.8       |             |             |
| ALT OF MDP                                                    |                         | 290                        |                          | LINE NO          | WIND DIR                 | WIND SPEED             | AIR TEMP    | AIR DENSITY |             |
|                                                               |                         |                            |                          | 02               | 2600                     | 21                     | 94.2        | 105.2       |             |
| BTRY ABOVE MDP (Δh)                                           |                         | 50                         |                          | Δh CORRECTION    |                          |                        | 00.1        | 00.5        |             |
| ALT OF TARGET (nearest meter)                                 |                         | 389                        |                          | CORRECTED VALUES |                          |                        | 94.1        | 104.7       |             |
| HEIGHT OF BURST ABOVE TARGET                                  |                         |                            |                          |                  |                          |                        |             |             |             |
| ALT OF BURST                                                  |                         | 389                        |                          |                  |                          |                        |             |             |             |
| ALT OF BTRY (nearest meter)                                   |                         | 336                        |                          |                  |                          |                        |             |             |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |                         | +53 ≈ +100                 |                          | COMP RG          | +27                      | CHART RG               | 5030        | ENTRY RG    | 5057 ≈ 5100 |
| WIND COMPONENTS AND DEFLECTION                                |                         |                            |                          |                  |                          |                        |             |             |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |                         | 6400                       |                          | TOT = MET + POS  |                          |                        |             |             |             |
| DIRECTION OF WIND                                             |                         | 2600                       |                          | R8 = L4 + R12    |                          |                        |             |             |             |
| DIRECTION OF FIRE (1451)                                      |                         | 1500                       |                          |                  |                          |                        |             |             |             |
| CHART DIRECTION OF WIND                                       |                         | 1100                       |                          |                  |                          |                        |             |             |             |
| CROSS WIND                                                    | WIND SPEED              | 21                         | + COMP                   | R                | .88                      | R                      | 18          | KNOTS       | 0.17        |
| RANGE WIND                                                    | WIND SPEED              | 21                         | + COMP                   | H                | .47                      | H                      | 10          | KNOTS       | 0.17        |
| CROSS WIND CORR                                               |                         |                            |                          |                  |                          |                        |             |             | 3.1         |
| MET DEFL CORR                                                 |                         |                            |                          |                  |                          |                        |             |             | 3.8         |
| MET RANGE CORRECTION                                          |                         |                            |                          |                  |                          |                        |             |             |             |
|                                                               | KNOWN VALUES            | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                     | MINUS                  |             |             |             |
| RANGE WIND                                                    | 10                      | 0                          | 10                       | +6.7             | +67.0                    |                        |             |             |             |
| AIR TEMP                                                      | 94.1                    | 100%                       | 5.9                      | +12.5            | 73.8                     |                        |             |             |             |
| AIR DENSITY                                                   | 104.7                   | 100%                       | 4.7                      | +5.9             | 27.7                     |                        |             |             |             |
| PROJ WEIGHT                                                   | 30                      | 40                         | 10                       | -35              | 35.0                     |                        |             |             |             |
| ROTATION                                                      |                         |                            | -29                      | .87              | 25.0                     |                        |             |             |             |
|                                                               |                         |                            |                          |                  | 168.5                    | 60.0                   |             |             |             |
|                                                               |                         |                            |                          |                  | 60.0                     |                        |             |             |             |
| MET RANGE CORR                                                |                         |                            |                          |                  | 108.5                    |                        | +108        |             |             |
| COMPUTATION OF VE                                             |                         |                            |                          |                  |                          |                        |             |             |             |
| PROP TEMP                                                     | +65                     | VE                         | -4.8                     | M/S              | D +28.0                  | TOTAL RANGE CORRECTION |             |             |             |
|                                                               |                         | CHANGE TO MV FOR PROP TEMP | -0.3                     | M/S              | I -21.6                  | MET RANGE CORRECTION   | +108        |             |             |
|                                                               |                         | ΔV                         | -5.1                     | M/S              | MV UNIT CORRECTION +28.0 | ΔV RANGE CORRECTION    | +143        |             |             |
|                                                               |                         |                            |                          |                  |                          | TOTAL RANGE CORRECTION | +251 ≈ +250 |             |             |
| OLD VE + NEW VE = +7 = AVG VE M/S                             |                         |                            |                          |                  |                          |                        |             |             |             |
| FS ~ EL 316 = 19.0 ~ 19.0 MET FUZE CORRECTION                 |                         |                            |                          |                  |                          |                        |             |             |             |
|                                                               | VARIATION FROM STANDARD | UNIT CORRECTION            | PLUS                     | MINUS            |                          |                        |             |             |             |
| ΔV                                                            | 5.1                     | -.054                      |                          | .275             | 5280                     |                        |             |             |             |
| RANGE WIND                                                    | 10                      | -.009                      |                          | .090             | +250 / 1                 |                        |             |             |             |
| AIR TEMP                                                      | 5.9                     | -.023                      |                          | .136             | 5030 3/6 19.0            |                        |             |             |             |
| AIR DENSITY                                                   | 4.7                     | -.006                      |                          | .028             | 19.0                     |                        |             |             |             |
| PROJ WEIGHT                                                   | 10                      | +.077                      | .077                     |                  |                          |                        |             |             |             |
|                                                               |                         |                            |                          | .077             | .529                     | TOTAL FUZE CORRECTION  |             |             |             |
|                                                               |                         |                            |                          | .077             |                          | MET FUZE CORRECTION    | -0.5        |             |             |
|                                                               |                         |                            |                          | .077             |                          | FUZE CORRECTION        | +0.5        |             |             |
|                                                               |                         |                            |                          | .452             |                          | TOTAL FUZE CORRECTION  | 0           |             |             |
| MET FUZE CORR                                                 |                         |                            |                          |                  |                          |                        |             |             |             |
| OLD FZ CORR + NEW FZ CORR = +2 = AVG FZ CORR                  |                         |                            |                          |                  |                          |                        |             |             |             |
| TARGET NO.                                                    |                         | BATTERY                    |                          |                  | DATE/TIME                |                        |             |             |             |

DA FORM 7, 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE

Figure 6-38. Octant II (800 mils to the right).

is known or unchanged from the previous met.

(2) Target altitude is the same as the battery altitude.

(3) Met line number is determined from table B.

(4) GFT setting is:

GFT A: Chg 4, Lot XY, Rg 3790, El 223, Ti 13.8.

(5) GFT df corr = total - drift

$$R14 = R9 - L5$$

#### 6-15. Met to a Target

a. Based on the transfer limits for a GFT setting, there are areas beyond 10,000 meters that are not covered by normal eight-direction met techniques. To place accurate fire on these areas, a GFT setting must be determined to each of these areas or a met must be solved to each target that is located in one of these areas. If a target appears in one of these areas that requires accurate surprise fire, a met to the target is solved using the same procedure as that used in solving a subsequent met. The line number of the met message to use is determined from table B by using chart range to the target and VI expressed to the nearest 100 meters. The direction of fire is the chart direction to the target.

b. Assume a target is to be engaged in an octant for which no GFT setting has been determined. Chart data to the target is as follows (all known data is the same as previous examples):

|            |      |
|------------|------|
| Range      | 6610 |
| Deflection | 3853 |
| Altitude   | 370  |

(1) All shaded blocks in figure 6-40 indicate data that is known or unchanged from the subsequent met in paragraph 6-12.

(2) The firing battery reports no change in propellant temperature.

(3) Met line number is determined from table B.

(4) The FDO will shoot charge 4GB, fuze time.

★ (5) The azimuth to the target is determined as follows:

|                            |             |
|----------------------------|-------------|
| Common deflection          | 3200        |
| Chart deflection to target | <u>3853</u> |
| Deflection increases       | 653         |
| (azimuth decreases 653)    |             |
| Azimuth of lay             | 610         |
| +6400                      | <u>6400</u> |
|                            | 7010        |
| -Change in azimuth         | <u>653</u>  |
| Azimuth to target          | 6357        |

(6) Data to fire:

Time: 26.7

Deflection: 3850 (3853 + R3 = 3850)

QE: 466 ((el 456) + (si +7) + (20/R +3))

c. There may be instances where only one battery has registered, thus only one position VE (that for the registering battery) is available. If a nonregistering battery is required to fire on a target outside transfer limits, position constants must be available for that battery to compute a met to a target. If calibration data for the registered charge is available, accurate position constants for the nonregistering batteries can be computed.

(1) *Position deflection correction.* With common directional control between batteries, the position deflection correction from the registering battery can be used for the nonregistering batteries. With no common control, a position deflection correction of zero should be used.

(2) *Position fuze correction.* The position fuze correction from the registering battery may be used for the nonregistering batteries if all batteries have the same fuze lot. Batteries having a different fuze lot should use zero.

(3) *Position VE.* If calibration data for the registered charge is available, the position VE for the registering battery must be modified for the nonregistering batteries. This is accomplished by adding the battalion base piece comparative VE of the nonregistering battery to the position VE of the registering battery. The result is the position VE for the nonregistering battery.

## MET TO MET CHECK GAGE POINT

| MET DATA CORRECTION SHEET                                     |                         |                            |                          |                  |                          |                        |             |             |             |
|---------------------------------------------------------------|-------------------------|----------------------------|--------------------------|------------------|--------------------------|------------------------|-------------|-------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                         |                            |                          |                  |                          |                        |             |             |             |
| BATTERY DATA                                                  |                         |                            |                          |                  | MET MESSAGE              |                        |             |             |             |
| CHARGE                                                        | ADJ DE                  | CHART RG                   | LATITUDE                 | TYPE MESSAGE     | OCTANT                   | AREA/UNIT              |             |             |             |
| 4GB                                                           |                         | 3790                       | 30°N                     | MET B 3          | 1                        | 342 988                |             |             |             |
| ALT OF BTRY (10m)                                             |                         | 340                        |                          | DATE             | TIME                     | ALT MDP                | PRESSURE    |             |             |
|                                                               |                         | 290                        |                          | 27               | 1430                     | 290                    | 100.8       |             |             |
| ALT OF MDP                                                    |                         | 290                        |                          | LINE NO.         | WIND DIR                 | WIND SPEED             | AIR TEMP    | AIR DENSITY |             |
|                                                               |                         | +50                        |                          | 81               | 2300                     | 20                     | 93.0        | 104.0       |             |
| BTRY ABOVE MDP (Ah)                                           |                         |                            |                          | Ah CORRECTION    |                          |                        | 0.01        | 0.5         |             |
| ALT OF TARGET (nearest meter)                                 |                         | 336                        |                          | CORRECTED VALUES |                          |                        | 94.9        | 103.5       |             |
| HEIGHT OF BURST ABOVE TARGET                                  |                         |                            |                          |                  |                          |                        |             |             |             |
| ALT OF BURST                                                  |                         | 336                        |                          |                  |                          |                        |             |             |             |
| ALT OF BTRY (nearest meter)                                   |                         | 336                        |                          |                  |                          |                        |             |             |             |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |                         | 0                          |                          | COMP RG          | 0                        | CHART RG               | 3790        | ENTRY RG    | 3790 ≈ 3800 |
| WIND COMPONENTS AND DEFLECTION                                |                         |                            |                          |                  |                          |                        |             |             |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |                         | 6400                       | TOT = MET + POS          |                  |                          |                        |             |             |             |
| DIRECTION OF WIND                                             |                         | 2300                       | R9 = L3 + R12            |                  |                          |                        |             |             |             |
| DIRECTION OF FIRE                                             |                         | 1500                       |                          |                  |                          |                        |             |             |             |
| CHART DIRECTION OF WIND                                       |                         | 800                        |                          |                  |                          |                        |             |             |             |
| CROSS WIND                                                    | WIND SPEED              | 20                         | x COM                    | R                | 71                       | R                      | 14          | KNOTS x     | 12          |
|                                                               |                         |                            |                          |                  |                          |                        |             | UNIT CORR   |             |
| RANGE WIND                                                    | WIND SPEED              | 20                         | x COM                    | R                | 71                       | = YAW                  | HEAD        | 14          | KNOTS       |
|                                                               |                         |                            |                          |                  |                          |                        |             |             |             |
| MET RANGE CORRECTION                                          |                         |                            |                          |                  |                          |                        |             |             |             |
|                                                               | KNOWN VALUES            | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                     | MINUS                  |             |             |             |
| RANGE WIND                                                    | 14                      | 0                          | 14                       | +4.9             | 68.6                     |                        |             |             |             |
| AIR TEMP                                                      | 94.9                    | 100%                       | 4.1                      | +10.0            | 41.0                     |                        |             |             |             |
| AIR DENSITY                                                   | 103.5                   | 100%                       | 3.5                      | +3.4             | 11.9                     |                        |             |             |             |
| PROJ WEIGHT                                                   | 30                      | 40                         | 10                       | -28              |                          | 28.0                   |             |             |             |
| ROTATION                                                      |                         | -25                        | x .87                    |                  |                          | 21.8                   |             |             |             |
|                                                               |                         |                            |                          |                  |                          | 121.5                  |             |             |             |
|                                                               |                         |                            |                          |                  |                          | 49.8                   |             |             |             |
|                                                               |                         |                            |                          |                  |                          | 71.7                   |             |             |             |
| MET RANGE CORR                                                |                         |                            |                          |                  |                          |                        | +72         |             |             |
| COMPUTATION OF VE                                             |                         |                            |                          |                  |                          |                        |             |             |             |
| PROP TEMP                                                     | +65 °F                  | VE                         | -4.8                     | M/S              | D+21.4                   | TOTAL RANGE CORRECTION |             |             |             |
|                                                               |                         | CHANGE TO MV FOR PROP TEMP | -0.3                     | M/S              | I-16.4                   | MET RANGE CORRECTION   | +72         |             |             |
|                                                               |                         | AV                         | -5.1                     | M/S              | MV UNIT CORRECTION +21.4 | AV RANGE CORRECTION    | +109        |             |             |
|                                                               |                         |                            |                          |                  |                          | TOTAL RANGE CORRECTION | +181 ≈ +180 |             |             |
| OLD VE + NEW VE = ±2 = AVG VE M/S                             |                         |                            |                          |                  |                          |                        |             |             |             |
| 13.6 ≈ 14                                                     |                         |                            |                          |                  |                          |                        |             |             |             |
| MET FUZE CORRECTION                                           |                         |                            |                          |                  |                          |                        |             |             |             |
|                                                               | VARIATION FROM STANDARD | UNIT CORRECTION            | PLUS                     | MINUS            |                          |                        |             |             |             |
| AV                                                            | 5.1                     | -.040                      |                          | .204             | 3970                     |                        |             |             |             |
| RANGE WIND                                                    | 14                      | -.007                      |                          | .098             | 3790 223 13.8            |                        |             |             |             |
| AIR TEMP                                                      | 4.1                     | -.017                      |                          | .070             | 13.6                     |                        |             |             |             |
| AIR DENSITY                                                   | 3.5                     | -.004                      |                          | .014             |                          |                        |             |             |             |
| PROJ WEIGHT                                                   | 10                      | +.059                      | .059                     |                  |                          |                        |             |             |             |
|                                                               |                         |                            | .059                     | .386             | TOTAL FUZE CORRECTION    |                        |             |             |             |
|                                                               |                         |                            |                          | .059             | MET FUZE CORRECTION      |                        |             |             |             |
|                                                               |                         |                            |                          | .059             | FUZE CORRECTION          |                        |             |             |             |
|                                                               |                         |                            |                          | .327             | TOTAL FUZE CORRECTION    |                        |             |             |             |
| MET FUZE CORR                                                 |                         |                            |                          |                  |                          |                        | +0.2        |             |             |
| OLD FZ CORR + NEW FZ CORR = ±2 = AVG FZ CORR                  |                         |                            |                          |                  |                          |                        |             |             |             |
| TARGET NO.                                                    | REG PT 1                |                            | BATTERY                  | A                |                          | DATE/TIME              | 29 Jun 2300 |             |             |

DA FORM 74200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
 \* U.S. G.P.O. 1977-765037/45

Figure 6-39. Met to met check gagepoint.

**Example:**

Given: B Battery registers and has a position VE of -3.8 m/s

Battalion base piece (BP) comparative VEs are: A, +1.7 m/s; B, 0 m/s; C, -2.9 m/s.

Required: Position VE for Batteries A and C

Solution:

A Battery

B Pos VE -3.8 m/s  
A Bn BP comp VE+(+1.7 m/s)  
A Pos VE -2.1 m/s

C Battery

B Pos VE -3.8 m/s  
C Bn BP comp VE+(-2.9 m/s)  
C Pos VE -6.7 m/s

If calibration data for the registered charge is not available, the accuracy of surprise fires for the nonregistering batteries cannot be predicted. The nonregistering batteries cannot deliver accurate predicted fire.

★

| NET DATA CORRECTION SHEET                                      |                         |                 |                  |              |                          |            |                       |                 |             |
|----------------------------------------------------------------|-------------------------|-----------------|------------------|--------------|--------------------------|------------|-----------------------|-----------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC. |                         |                 |                  |              |                          |            |                       |                 |             |
| BATTERY DATA                                                   |                         |                 |                  |              | NET MESSAGE              |            |                       |                 |             |
| CHARGE                                                         | ADG                     | CHARGE NO.      | LATITUDE         | TYPE MESSAGE | STATION                  | PRECEDENCE |                       |                 |             |
| 4GB                                                            |                         | 6610            | 30°N             | MET B3       | 1                        | 342988     |                       |                 |             |
| ALT OF BTRY (10M)                                              |                         | 340             | 27               | 1430         | 290                      | 108.8      |                       |                 |             |
| ALT OF MOP                                                     |                         | 290             | 03               | 2900         | 21                       | 94.1       |                       |                 |             |
| STATION ELEVATION (10M)                                        |                         | 50              | A & B CORRECTION |              | 0.01                     | 0.05       |                       |                 |             |
| ALT OF TARGET (nearest meter)                                  |                         | 370             | CORRECTED VALUES |              | 94.0                     | 104.6      |                       |                 |             |
| HEIGHT OF BUNST ABOVE TARGET                                   |                         |                 |                  |              |                          |            |                       |                 |             |
| ALT OF BUNST                                                   |                         | 370             |                  |              |                          |            |                       |                 |             |
| ALT OF BTRY (nearest meter)                                    |                         | 336             |                  |              |                          |            |                       |                 |             |
| HEIGHT OF TARGET (nearest meter) ABOVE GUN NO                  |                         | +34 ± 0         | COMP NO.         | 0            | CHARGE NO.               | 6610       | ENTRANCE              | 6610            | 6600        |
| WIND COMPONENTS AND DEFLECTION                                 |                         |                 |                  |              |                          |            |                       |                 |             |
| WIND DIRECTION OF WIND IS LESS THAN OR FINE ADD                |                         | 400             | TOT = MET + POS  |              |                          |            |                       |                 |             |
| DIRECTION OF WIND                                              |                         | 2900            | R3 = L9 + R12    |              |                          |            |                       |                 |             |
|                                                                |                         | 9300            |                  |              |                          |            |                       |                 |             |
| DIRECTION OF FIRE                                              |                         | 6351            |                  |              |                          |            |                       |                 |             |
|                                                                |                         | 6400            |                  |              |                          |            |                       |                 |             |
| CHART DIRECTION OF WIND                                        |                         | 2900            |                  |              |                          |            |                       |                 |             |
| CROSS WIND                                                     |                         | 21              | COMP             | 0.29         | 0.6                      | KNOTS      | 0.23                  | CROSS WIND CORN | 0.14        |
| RANGE WIND                                                     |                         | 21              | COMP             | 0.96         | 0.6                      | KNOTS      | 20                    | NET DRIFT CORN  | 0.03 L9     |
| NET RANGE CORRECTION                                           |                         |                 |                  |              |                          |            |                       |                 |             |
| RANGE WIND                                                     |                         | 0.20            | STANDARD VALUES  | 0            | VARIATIONS FROM STANDARD | 0.20       | UNIT CORRECTIONS      | PLUS            | MINUS       |
| AIR TEMP                                                       |                         | 94.0            | 100%             | 0            | 6.0                      | +14.4      | 86.4                  |                 | 66.0        |
| AIR DENSITY                                                    |                         | 104.6           | 100%             | 0            | 4.6                      | +9.8       | 45.1                  |                 |             |
| PROJ HEIGHT                                                    |                         | 370             | 40               | 10           | -42                      |            |                       |                 | 42.0        |
| NOTATION                                                       |                         |                 | 0                |              |                          |            |                       |                 |             |
|                                                                |                         |                 |                  |              |                          |            |                       |                 | 131.5 108.0 |
|                                                                |                         |                 |                  |              |                          |            |                       |                 | 108.0       |
| NET RANGE CORR                                                 |                         |                 |                  |              |                          |            |                       |                 | 23.5        |
|                                                                |                         |                 |                  |              |                          |            |                       |                 | +24         |
| COMPUTATION OF VE                                              |                         |                 |                  |              |                          |            |                       |                 |             |
| PROJ +65                                                       | VE                      | -4.8            | D                | +35.3        | TOTAL RANGE CORRECTION   |            |                       |                 |             |
| CHANGE TO MV FOR PROJ TEMP                                     | BY                      | -0.3            | I                | -27.7        | NET RANGE CORRECTION     |            |                       |                 | +24         |
|                                                                | BY                      | -5.1            | W                | 35.3         | AV RANGE CORRECTION      |            |                       |                 | +180        |
|                                                                |                         |                 |                  |              | TOTAL RANGE CORRECTION   |            |                       |                 | +204 ± 200  |
| OLD VE                                                         |                         |                 |                  |              |                          |            |                       |                 |             |
| FS-EL 456 = 26.7 ± 27 NET FUZE CORRECTION                      |                         |                 |                  |              |                          |            |                       |                 |             |
| AV                                                             | VARIATION FROM STANDARD | UNIT CORRECTION | PLUS             | MINUS        |                          |            |                       |                 |             |
|                                                                | 0.51                    | -0.076          |                  | .388         | 1200 6810                |            |                       |                 |             |
| RANGE WIND                                                     | 0.20                    | +0.003          |                  | .060         | 6610 456 26.7            |            |                       |                 |             |
| AIR TEMP                                                       | 6.0                     | -0.030          |                  | .180         | 26.7°                    |            |                       |                 |             |
| AIR DENSITY                                                    | 4.6                     | -0.012          |                  | .055         |                          |            |                       |                 |             |
| PROJ HEIGHT                                                    | 10                      | +0.106          |                  | .106         |                          |            |                       |                 |             |
|                                                                |                         |                 |                  |              | 16.6                     | .623       | TOTAL FUZE CORRECTION |                 |             |
|                                                                |                         |                 |                  |              | 16.6                     | .623       | NET FUZE CORRECTION   |                 |             |
|                                                                |                         |                 |                  |              | 16.6                     | .623       | FUZE CORRECTION       |                 |             |
|                                                                |                         |                 |                  |              | 4.57                     | .0         | TOTAL FUZE CORRECTION |                 |             |
|                                                                |                         |                 |                  |              | 4.57                     | .0         |                       |                 |             |
| NET FUZE CORR                                                  |                         |                 |                  |              |                          |            |                       |                 |             |
| OLD FZ CORR                                                    |                         |                 |                  |              |                          |            |                       |                 |             |
| NEW FZ CORR                                                    |                         |                 |                  |              |                          |            |                       |                 |             |
| DATE/TIME                                                      |                         |                 |                  |              |                          |            |                       |                 |             |

DA FORM 4200 JAN 74 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE. © U.S. GPO: 1974-860-841/8331

Figure 6-40. Met to a target.

## Section VI. FADAC MET

### 6-16. Predicted Fire

a. Predicted fire is the technique of computing firing data to a specific target accurately taking into account all factors that affect the ballistic trajectory.

b. Using FADAC with all ballistic data known and input, predicted fire computations can be made to any target that lies within the range capability of the weapon. The predicted fire requirements are:

(1) Known battery location that is normally determined by accurate survey.

(2) Known target location accurately determined by target acquisition means.

(3) Known weapon-ammunition data of projectile weight, powder temperature, and muzzle velocity.

(4) Accurate meteorological data as required in the computer met message.

(5) Accurate computational capability of FADAC. When FADAC computes the ballistic trajectory, using a numerical integration technique, each zone of the meteorological data entered is considered in the computations. The trajectory is solved in increments for a fraction of time. The atmospheric effect is calculated for each increment. The manual determination of meteorological corrections include corrections for propellant temperatures, projectile weight, and rotation to determine

the effect of all known parameters except muzzle velocity. Using the same technique of determining the position velocity error, the FADAC will compute the same data with a higher degree of accuracy.

### 6-17. Registration Corrections and Updating Met

a. When a registration is conducted, the met used by FADAC should be the latest weather data and should reflect the weather conditions as they actually exist during the firing. Then if a change in the weather occurs and a new met is received, the only action necessary is to enter the new met. The registration corrections will remain unchanged.

b. If a registration is conducted using an old met or standard met and the residual corrections have been computed and applied and subsequently a met is received that was valid at the time the registration was fired, then the valid met should be entered and the registration corrections recomputed and reapplied.

c. If a registration is conducted using the old met or standard met, and a change in the weather occurs and a new met is received, the registration corrections are no longer valid. In this case, corrections must be set to zero, the new met entered, and another registration conducted.

# CHAPTER 7

## CALIBRATION

### Section I. CALIBRATION DESCRIPTION

#### 7-1. Reasons for Calibration

a. The muzzle velocity developed in a field artillery weapon is the measure of its shooting strength. If accurate artillery fire is to be obtained, shooting strength of a weapon-ammunition combination must be known. Firing tables give velocities and ranges for a standard weapon firing standard ammunition under standard conditions. However, ranges and velocities obtained in actual firing differ from those in the firing tables because of variations in manufacture of the weapon and ammunition, wear in the weapon, nonstandard conditions, or a combination of these factors. Two pieces of the same caliber, firing the same charge and elevation, will seldom deliver fire at exactly the same range. Calibration is the comparison of the muzzle velocity of a given piece with an accepted standard performance. That standard may be selected

arbitrarily from the performance of a group of weapons being calibrated together, as in comparative calibration, or it may be the standard defined in the firing tables, as in absolute calibration (fig 7-1).

b. After the relative shooting strength of each weapon is known, corrections can be determined and applied to correct for the increase or decrease in shooting strength.

#### ★ 7-2. Frequency of Calibration

a. All new pieces of a given caliber and model will not necessarily develop the same muzzle velocity because of the tolerances that are allowed in the size of the powder chamber and in the dimensions of the bore. If a battalion armed with new pieces fired all of them with a common lot of ammunition, a velocity spread of 3 or 4 meters per second (m/s) between the piece with the highest



Figure 7-1. Comparative and absolute calibration results.



muzzle velocity and the piece with the lowest muzzle velocity would not be unusual. Therefore, pieces must be calibrated as soon as possible after receipt or when retubed.

b. The type and caliber of the weapon that is being fired and its frequency of firing determine the need for calibration. With the issuance of the M90 radar chronograph (velocimeter), all new tubes should be calibrated immediately upon receipt. Thereafter, each weapon would be recalibrated each 250 erosion EFC (equivalent full charge) rounds or whenever the validity of the calibrated muzzle velocity is questioned. Chief factors contributing to the loss in muzzle velocity for a piece are the number of rounds that have been fired through the tube and the charges used. Higher charges increase tube wear, which in turn, tends to decrease muzzle velocity. Guns, because of their higher velocities, tend to display tube wear more quickly than howitzers. If a great deal of firing takes place, recalibration may be needed more often. Methods of determining when recalibration may be necessary are outlined below.

(1) If an accurate record of the changes in VE determined from concurrent meteorological data is maintained, it may be used as a guide for determining the need for recalibration. When the velocity loss since the last calibration is equivalent to two range probable errors, the need for recalibration is indicated. (An indicator of this is a loss of 1.5 m/s, which closely approximates two range probable errors.)

**Example:**

An M109A1 unit calibrated with charge 4GB. The average position VE at that time was -3.4 m/s. The FDO needs to know what his position VE must be before recalibration may be required.

**Solution:**

(a) Choose an arbitrary midrange for the charge in question: Rg 5000.

(b) From table G, determine the PER: 17 meters.

(c) From table F, column 10, determine the correction in range for a 1 m/s decrease in muzzle velocity: +27.5 meters.

(d) Determine the decrease in muzzle velocity that will require a correction in meters of two PER.

$2 (PE_R) \div \text{col 10 correction factor} = \text{decrease in MV.}$

$2(17) \div (27.5) = 1.2.$

A 1.2 m/s loss in velocity (-1.2 m/s) is equivalent to two PER.

(e) Apply the decrease to the current average position VE.  $(-3.4 \text{ m/s}) + (-1.2 \text{ m/s}) = -4.6 \text{ m/s.}$

When the average position VE reaches -4.6 m/s, recalibration may be necessary.

(2) The extent of tube wear near the beginning of the rifling of the bore gives a fair indication of the loss in muzzle velocity and the remaining tube life. Precise measurement of the distance between the lands in the bore near the start of the rifling can be made with a pullover gage. Support maintenance has this gage and makes the measurement. The wear measurement, when compared with the data in the "wear" table (Approximate Losses in Muzzle Velocity Table) in the introduction of each firing table, can be used in estimating the loss in muzzle velocity.

**Example:**

An M109A1 unit calibrated with CHG 4GB; the wear measurement was 6.143 inches. The FDO needs to determine when recalibration is indicated.

**Solution:**

(a) The loss in muzzle velocity equating to a wear measurement of 6.142 inches is -3.1 m/s (table, page XI, TFT 155-AM-1).

(b) The loss in muzzle velocity equating to 2 PER is -1.2 (determined in previous example).

(c) Determine the approximate velocity loss when recalibration is indicated  $(-3.1 \text{ m/s}) + (-1.2 \text{ m/s}) = -4.3 \text{ m/s.}$

(d) Determine the closest wear measurement corresponding to the velocity loss from the table on page XI.

When the wear measurement is 6.150 inches, recalibration is indicated.

### 7-3. Methods of Calibration

★ Calibration can be accomplished with the aid of a muzzle velocity measuring device called a chronograph, by fall-of-shot procedures of varying complexity, or with a velocimeter. All techniques measure the variation from the accepted standard performance expressed in meters per second. If the variation is determined by a chronograph or velocimeter, it is called a muzzle velocity variation (MVV). If the variation is determined from fall-of-shot procedures, it is called a velocity error. The M90 velocimeter is the preferred technique. The M36 chronograph will be used until the unit receives the velocimeter. The muzzle velocity of a given weapon varies from charge to charge. The only method of determining the muzzle velocity for a particular charge is to calibrate with that charge. Normally, calibration is accomplished for only one or two charges. The battalion S3 will select the charges based on the ranges most frequently fired. Eight rounds per piece per charge is recommended. This includes two warming rounds, which are to be disregarded if they seem erratic. The calibration can be done with fewer rounds, with a possible reduction in accuracy and data reliability.

*a. M36 Radar Chronograph Method.* Chronographs of the radar doppler type are organic to division artilleries. They are more flexible than skyscreen equipment used by ordnance calibration teams and are capable of day and night operation. The chronograph organic to field artillery units is the radar chronograph set M36 (fig 7-2). It is a portable electronic instrument that measures weapon-projectile velocities ranging from 75 to 1860 meters per second; the accuracy attained is equal to the accuracy attained with the skyscreen type of chronograph. The M36 operates on the principle that the frequency of the transmitted waves will change when reflected from a moving projectile. The difference in frequencies between the transmitted and received signals is measured and is converted by electronic circuitry to an indicated velocity, which is read directly in meters per second. The M36 operates from a

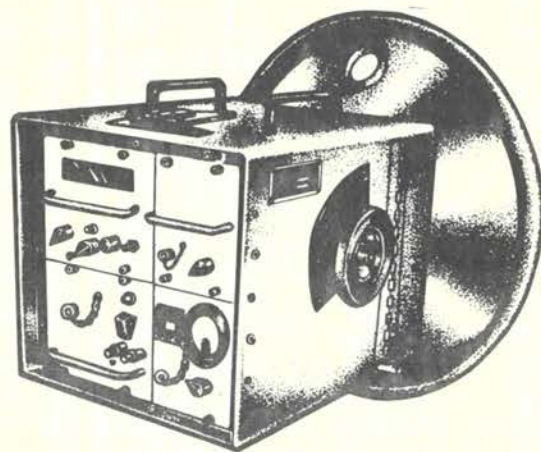


Figure 7-2. Radar chronograph set M-36.

vehicle or ground mount to the side of the weapon and is laid parallel to the weapon. The chronograph can follow changes in direction and elevation as fast as the piece can be laid. This speed and the lack of intensive preparation permit calibration whenever firing is being conducted and an M36 chronograph is available. After each round is fired, the chronograph displays a readout velocity, which is the indicated velocity of the projectile at some point along the trajectory as determined by the DELAY selector switch. The readout velocity must be corrected for all nonstandard conditions except those of tube wear and propellant efficiency. The corrected velocity is the muzzle velocity the weapon achieves with the propellant lot and charge used for the calibration. Readout velocities are converted to muzzle velocities under standard conditions by means of FADAC or by the use of extrapolation tables. For manual computation procedures, extrapolation tables, and more information on the M36 chronograph, see TM 9-1290-325-12/2.

*b. Skyscreen Chronograph Method.* The chronograph used by the ordnance teams is usually the skyscreen type. More planning and coordination must be accomplished prior to calibrating with the skyscreen than with the radar chronograph M36. This type calibration is established as a separate firing



for the battalion on a given day or days. Normally, the battalion S3 is responsible for the planning, coordination, and conduct of this exercise.

(1) The skyscreen is a set of photoelectric cells that are placed along a carefully surveyed base. The base is established along the prolongation of the tube. Passage of the projectile overhead changes the light intensity striking the cells, which in turn activates an electric time counter. The ordnance team computes the mean developed muzzle velocity of the rounds fired from each weapon and compensates for the effect of nonstandard conditions to determine the muzzle velocity.

(2) The procedures for calibration conducted by an ordnance team using the skyscreen are as follows: A bench-checked (ordnance-tested) gunner's quadrant should

be available, and all propellant thermometers to be used should be calibrated. The firing point selected must be free of trees, must have a minimum of underbrush, and must be as level as possible out to 200 meters in front of the weapon. An area approximately 30 meters behind and slightly to one side of the firing point must be set aside for the calibration van. A traffic pattern must be laid out and must be enforced so that no traffic crosses the calibration team's cables between the van and the screens. The deflection and quadrant elevation selected must be such that all rounds fired will fall within safety limits. The selection of suitable firing data is important, since even a small change in firing data requires repositioning of the screens, which takes as much time as the original positioning (fig 7-3).

(3) When more than one weapon is being calibrated, it is preferable to fire all pieces

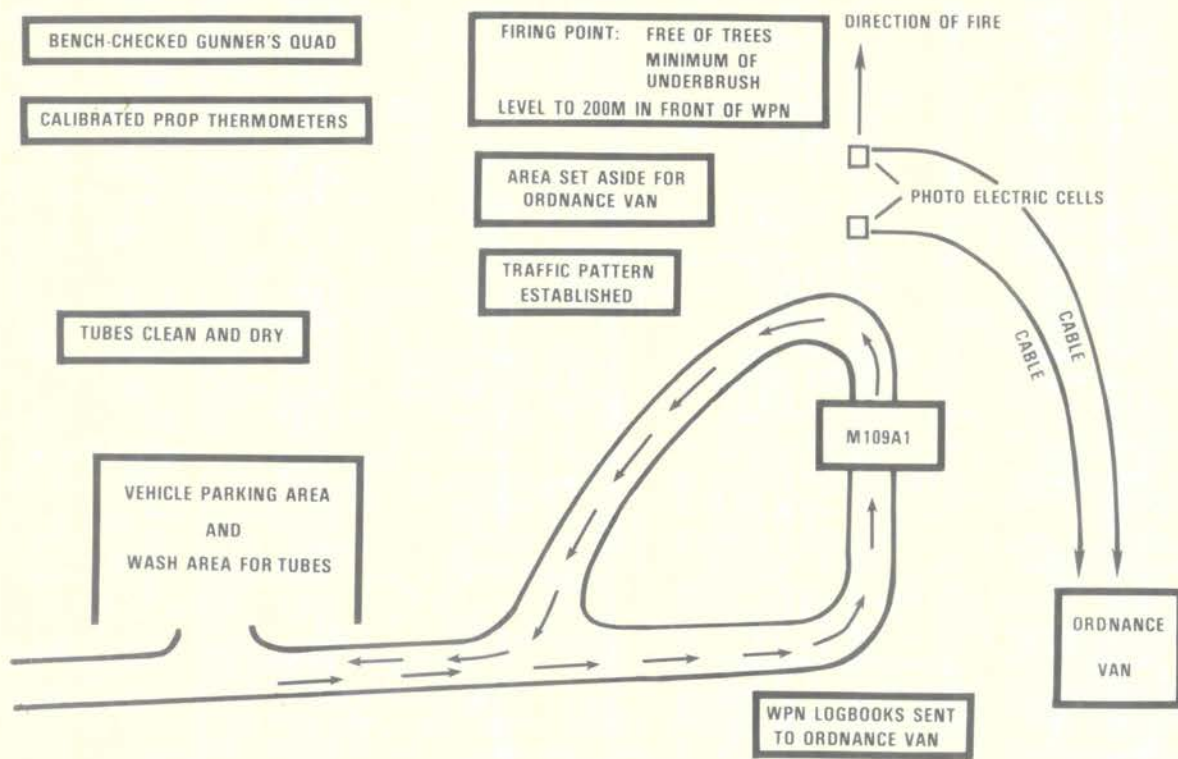


Figure 7-3. Calibration position.

successively from the same position while skyscreens remain in place. The first piece is moved into position and laid, and the position is staked so that subsequent pieces will stop on the same spot. The calibration team then emplaces the skyscreens by sighting through the tube. When each weapon is moved to the position marked by the stake, the crew lays the tube by sighting through it directly over the screens, takes a sight picture, and corrects aiming post displacement. Since the tube is centered over the skyscreens, which have not been moved, it is laid on the selected azimuth and is therefore safe. Logbooks for each weapon are delivered to the ordnance team as the piece comes to the firing point. After the piece is calibrated, the ordnance team records the muzzle velocity on the DA Form 2408-4 and returns the logbook to the section.

*c. Fall-of-Shot Method.* The fall-of-shot method is more complex than any other method. A group of rounds is fired by each weapon, and the mean point of impact determined. Both comparative and absolute calibration can be accomplished with fall-of-shot procedures. Detailed procedures are described in section III.

★ *d. Velocimeter Method.* The M90 radar chronograph (velocimeter) method simplifies the procedures currently used with the M36 chronograph. The velocimeter consists of three operating units: the antenna, data, and system test units. The antenna will be attached to a nonrecoiling part of the howitzer, transmitting a readout of muzzle velocity to the display unit after each round is fired. Data displayed is:

(1) Readout muzzle velocity of the last round fired.

(2) The average readout muzzle velocity of the last eight rounds.

(3) The number of rounds used in the average calculation of readout muzzle velocity.

The readout MV can be displayed at any QE fired, and the velocimeter can be switched

from one weapon to another weapon with ease. Detailed procedures are in section V.

#### ★ 7-4. Use of Calibration Data

a. Calibration makes it possible to group cannons of a given caliber and nearly equal muzzle velocities into one battery to reduce the frequency with which individual piece corrections must be applied (fig 7-4).

b. Calibration data can be used for:

(1) Selecting base pieces after the weapons have been grouped.

(2) Determining the battery comparative VEs.

(3) Determining the battalion base piece comparative VEs for the transfer of GFT settings.

(4) Determining corrections that will compensate for the variations in muzzle velocity developed by individual pieces. (The data determined by calibration, whether absolute or comparative, can be used.)

(5) Determining the necessary corrections to compensate for the increased depth of a battery position encountered when terrain positioning is used.

(6) Determining data for the attack of irregularly shaped targets.

| BATTERY A |  | MV               | CLOSEST TO THE AVERAGE<br>NO CALIBRATION CORRECTIONS |
|-----------|--|------------------|------------------------------------------------------|
| 501       |  | -0.7             |                                                      |
| 504       |  | -1.3             |                                                      |
| 506       |  | -1.4             |                                                      |
| 511       |  | -1.6 BP          | TUBE 511 IS SELECTED AS<br>BTRY A BP                 |
| 512       |  | -2.1             |                                                      |
| 508       |  | -2.7             |                                                      |
|           |  | -9.8 ÷ 6 = 1.63  |                                                      |
| BATTERY B |  | MV               | CLOSEST TO THE AVERAGE<br>NO CALIBRATION CORRECTIONS |
| 507       |  | -3.5             |                                                      |
| 505       |  | -3.9             |                                                      |
| 502       |  | -4.9 BP          | TUBE 502 IS SELECTED AS<br>BTRY B BP                 |
| 509       |  | -5.0             |                                                      |
| 515       |  | -5.5             |                                                      |
| 514       |  | -5.9             |                                                      |
|           |  | -28.7 ÷ 6 = 4.78 |                                                      |

Figure 7-4. Grouping of cannons by muzzle velocity, one piece requiring corrections.



(7) Transferring GFT settings to the nonregistering batteries and determining GFT settings when a piece other than base piece fires a registration.

(8) Determining data for nuclear missions that require more precise computations.

(9) Determining GFT settings. Battlefield conditions may require the use of MVV as determined by absolute calibration to be used in computing a GFT setting ( $\text{met} + \text{MVV}$ ). When a unit has not registered and has not solved a concurrent met, the MVV can be used as a position VE until one becomes available. (An absolute VE from fall-of-shot calibration can also be used.)

## Section II. CHRONOGRAPH CALIBRATION COMPUTATIONS

### 7-5. Determination of Muzzle Velocity Variation

After the muzzle velocities have been determined by absolute calibration, the muzzle velocity variation must be determined. As the term implies, it is a variation in muzzle velocity *from the standard* muzzle velocity listed in the firing tables for each charge. If the muzzle velocity of a weapon is greater than the firing table muzzle velocity, the difference is a positive MVV. Conversely, if the muzzle velocity is less than the firing table muzzle velocity, the difference is a negative MVV (fig 7-5).

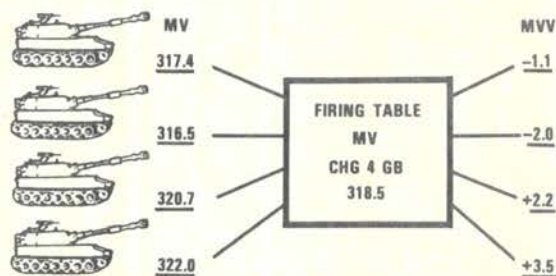


Figure 7-5. Determination of muzzle velocity variation (MVV).

(1) If he groups his weapons, fewer weapons should need individual piece corrections (as discussed in para 7-11).

(2) If he does not group his weapons, the alternative is to position weapons in the battery to compensate for their shooting strength (e.g., no. 6 is a short shooter, and is always positioned forward). There are two drawbacks to this approach. First, corrections by positioning are valid only close to the azimuth of lay, and for the range at which the meter correction was determined. Second, the terrain of the firing position may not allow such positioning.

b. Ideally, weapons are assigned to the particular batteries on the basis of their

### 7-6. Grouping of Weapons

a. One of the most important uses of calibration data is for grouping the weapons of a particular battalion. Proper grouping will serve to eliminate or reduce the requirement for individual piece corrections within a particular battery. Normally, there is a reluctance on the part of subordinate commanders and section chiefs to exchange the weapons required in the grouping process. The commander makes the decision of whether or not to group his weapons based on the following factors:

shooting strengths, determined by their MVVs. Within a battalion, the strongest shooters (four or six, depending on the caliber of weapon) normally are assigned to one battery, the weakest shooters to another, and the remaining weapons to the other battery. MVVs (absolute calibration data) permit the most effective grouping.

★ **Example:**

The results of an M36/M90 chronograph calibration are given after the chronograph readouts have been reduced to weapon muzzle velocities. After the MVVs were determined, a grouping took place within the battalion based on the commander's guidance. Results of the M36 chronograph calibration are shown in figure 7-6. Commander's guidance: Strongest shooters, Battery A; weakest shooters, Battery C.

### 7-7. Selection of Base Pieces

Within each battery, the base piece normally should be the piece whose shooting strength is nearest the battery average. To determine the battery average, add the six MVVs and

| TUBE NO | WPN MV | STD MV | MVV   | GROUP WEAPONS |         |       |
|---------|--------|--------|-------|---------------|---------|-------|
|         |        |        |       | UNIT          | TUBE NO | MVV   |
| 501     | 317.8  | 318.5  | -0.7  | <b>A</b>      | 501     | -0.7  |
| 502     | 313.6  |        | -4.9  |               | 504     | -1.3  |
| 503     | 310.8  |        | -7.7  |               | 506     | -1.4  |
| 504     | 317.2  |        | -1.3  |               | 511     | -1.6  |
| 505     | 314.6  |        | -3.9  |               | 512     | -2.1  |
| 506     | 317.1  |        | -1.4  |               | 508     | -2.7  |
| 507     | 315.0  | 318.5  | -3.5  | <b>B</b>      | 507     | -3.5  |
| 508     | 315.8  |        | -2.7  |               | 505     | -3.9  |
| 509     | 313.5  |        | -5.0  |               | 502     | -4.9  |
| 510     | 311.3  |        | -7.2  |               | 509     | -5.0  |
| 511     | 316.9  |        | -1.6  |               | 515     | -5.5  |
| 512     | 316.4  |        | -2.1  |               | 514     | -5.9  |
| 513     | 312.2  | 318.5  | -6.3  | <b>C</b>      | 513     | -6.3  |
| 514     | 312.6  |        | -5.9  |               | 510     | -7.2  |
| 515     | 313.0  |        | -5.5  |               | 503     | -7.7  |
| 516     | 310.2  |        | -8.3  |               | 516     | -8.3  |
| 517     | 308.1  |        | -10.4 |               | 518     | -9.0  |
| 518     | 309.5  |        | -9.0  |               | 517     | -10.4 |

DATE 13 MAR

LOT XY

CHG 4GB

divide the total by 6. Select as the base piece the piece that is closest to that average. If selection of the average piece requires a

#### Battery A MVV

|     |                     |
|-----|---------------------|
| 501 | -0.7                |
| 504 | -1.3                |
| 506 | -1.4                |
| 511 | -1.6 BP             |
| 512 | -2.1                |
| 508 | -2.7                |
|     | <hr/>               |
|     | -9.8      6 = -1.63 |

Closest to the average selected  
No calibration corrections

Tube 511 is selected as btry A BP

#### Battery B MVV

|     |                      |
|-----|----------------------|
| 507 | -3.5                 |
| 505 | -3.9                 |
| 502 | -4.9 BP              |
| 509 | -5.0                 |
| 515 | -5.5                 |
| 514 | -5.9                 |
|     | <hr/>                |
|     | -28.7      6 = -4.78 |

Closest to the average selected  
No calibration corrections

Tube 502 is selected as Btry B BP

#### Battery C MVV

|     |                             |
|-----|-----------------------------|
| 513 | -6.3                        |
| 510 | -7.2                        |
| 503 | -7.7 BP                     |
| 516 | -8.3                        |
| 518 | -9.0 (Individual piece      |
| 517 | -10.4 corrections required) |
|     | <hr/>                       |
|     | -48.9      6 = -8.15        |

Closest to average not selected

One piece requires calibration corrections

Tube 503 is selected as Btry C base piece

*Note.* Selection of piece 516 would have required calibration corrections for two pieces (513 and 517).

★ Figure 7-6. Results of M36 chronograph calibration.

Figure 7-7. Selection of base piece.

calibration correction for one or more of the pieces, then another piece may be designated the base piece. A calibration correction should be applied to any piece whose battery comparative VE varied by more than  $\pm 1.5$  meters per second from that of the base piece (fig 7-7).

#### **7-8. Determination of Battery Comparative VEs**

With the base piece selected, the next step is to determine the battery comparative VEs. As the term "comparative" implies, this VE is determined by comparison of one weapon with another. The weapon used for comparison is the battery base piece. The comparative VE of the base piece is 0 meters per second. For each of the remaining weapons, the battery comparative VE is determined as a difference between the weapon MVV and the base piece MVV. If the weapon MVV is smaller than the base piece MVV, the difference is a positive comparative VE. If the weapon MVV is greater than the base piece MVV, the difference is a negative comparative VE. Another technique for determining the battery comparative VEs is to algebraically add to the MVV of each of the remaining weapons the same value that was added to bring the base piece MVV to zero. An example is shown in figure 7-8.

#### **7-9. Determination of Battalion Base Piece Comparative VE**

The battalion base piece comparative VEs are used in the transfer of GFT settings from the registering battery to the nonregistering batteries. The procedures for determining battalion base piece comparative VEs are basically the same as those discussed in paragraph 7-8 except only the base pieces are used. The base piece of the battery that registered is set to standard (0 meters per second) and the other base pieces are then compared to it. Figure 7-8 shows the battalion base piece comparative VEs for each battery. It is based on the information in figures 7-5 and 7-6.

#### **7-10. Transfer of GFT Settings**

a. When only one battery of a battalion equipped with weapons of the same caliber is allowed to register, the GFT setting of the registering battery is transferred to the nonregistering batteries in the absence of better information. If either the MVVs or the comparative or absolute VEs (fall of shot) of the base pieces of the batteries are known, they may be used to obtain GFT settings for the nonregistering batteries. These GFT settings will approach the accuracy of the GFT settings that would have been obtained if all batteries had registered. Registrations should be limited; the need to transfer GFT settings will therefore be the rule rather than the exception.

b. The procedure for determining the GFT setting for a nonregistering battery is as follows:

(1) Determine the battalion base piece comparative VEs of the nonregistering battery base piece by following the procedure outlined in paragraph 7-9. Remember that the base piece of the registering battery is set to standard (0 meters per second).

(2) Determine a VE range correction by multiplying the battalion base piece comparative VE ((1) above) by the muzzle velocity unit correction factor (table F) corresponding to the entry range for the registering battery. Complementary range must be considered in determining the entry range (table B).

(3) Determine a VE corrected range for the nonregistering battery by algebraically adding the VE range correction to the GFT range of the registering battery.

(4) Using the GFT setting for the registering battery, determine the elevation and fuze setting corresponding to the corrected range ((3) above).

(5) Construct the GFT setting by placing the hairline over the range to the registration point for the registering battery and drawing the elevation gageline over the elevation determined in (4) above.

| CALIBRATION DATA |        |        |       |               |         |       |           |      | BN BP COMP VE                        |                                      |                                      |
|------------------|--------|--------|-------|---------------|---------|-------|-----------|------|--------------------------------------|--------------------------------------|--------------------------------------|
| TUBE NO          | WPN MV | STD MV | MVV   | GROUP WEAPONS |         |       | BTRY COMP |      | A                                    | B                                    | C                                    |
|                  |        |        |       | UNIT          | TUBE NO | MVV   | BP        | VE   |                                      |                                      |                                      |
| 501              | 317.8  | 318.5  | -0.7  | <b>A</b>      | 501     | -0.7  |           | +0.9 | A BTRY REGISTERED<br>TRANSFER TO B&C | B BTRY REGISTERED<br>TRANSFER TO A&C | C BTRY REGISTERED<br>TRANSFER TO A&B |
| 502              | 313.6  |        | -4.9  |               | 504     | -1.3  |           | +0.3 |                                      |                                      |                                      |
| 503              | 310.8  |        | -7.7  |               | 506     | -1.4  |           | +0.2 |                                      |                                      |                                      |
| 504              | 317.2  |        | -1.3  |               | 511     | -1.6  | BP        | 0.0  |                                      |                                      |                                      |
| 505              | 314.6  |        | -3.9  |               | 512     | -2.1  |           | -0.5 |                                      |                                      |                                      |
| 506              | 317.1  |        | -1.4  |               | 508     | -2.7  |           | -1.1 |                                      |                                      |                                      |
| 507              | 315.0  |        | -3.5  | <b>B</b>      | 507     | -3.5  |           | +1.4 | 0.0                                  | +3.3                                 | +6.1                                 |
| 508              | 315.8  |        | -2.7  |               | 505     | -3.9  |           | +1.0 |                                      |                                      |                                      |
| 509              | 313.5  |        | -5.0  |               | 502     | -4.9  | BP        | 0.0  |                                      |                                      |                                      |
| 510              | 311.3  |        | -7.2  |               | 509     | -5.0  |           | -0.1 |                                      |                                      |                                      |
| 511              | 316.9  |        | -1.6  |               | 515     | -5.5  |           | -0.6 |                                      |                                      |                                      |
| 512              | 316.4  |        | -2.1  |               | 514     | -5.9  |           | -1.0 |                                      |                                      |                                      |
| 513              | 312.2  |        | -6.3  | <b>C</b>      | 513     | -6.3  |           | +1.4 | -3.3                                 | 0.0                                  | +2.8                                 |
| 514              | 312.6  |        | -5.9  |               | 510     | -7.2  |           | +0.5 |                                      |                                      |                                      |
| 515              | 313.0  |        | -5.5  |               | 503     | -7.7  | BP        | 0.0  |                                      |                                      |                                      |
| 516              | 310.2  |        | -8.3  |               | 516     | -8.3  |           | -0.6 |                                      |                                      |                                      |
| 517              | 308.1  |        | -10.4 |               | 518     | -9.0  |           | -1.3 |                                      |                                      |                                      |
| 518              | 309.5  |        | -9.0  |               | 517     | -10.4 |           | -2.7 |                                      |                                      |                                      |

DATE 13 MAR

LOT XY

CHG 4GB

Figure 7-8. Determination of battalion base piece comparative VE.

(6) Draw the time gageline over the fuze setting obtained in (4) above.

c. The GFT deflection correction remains the same for all batteries, but each battery must determine its own total deflection correction. The nonregistering battery determines the drift corresponding to its adjusted elevation and algebraically adds the drift to its GFT deflection correction. The result is the total deflection correction for the nonregistering battery.

**Example:**

Battery B, 155-mm M109A1 howitzer, has registered and determined the following GFT setting: GFT B, Chg 4, Lot XY (GB), Rg 5140, El 324, Ti 18.9.

Alt reg pt 1  
Alt Btry B

377

352

+25

VI

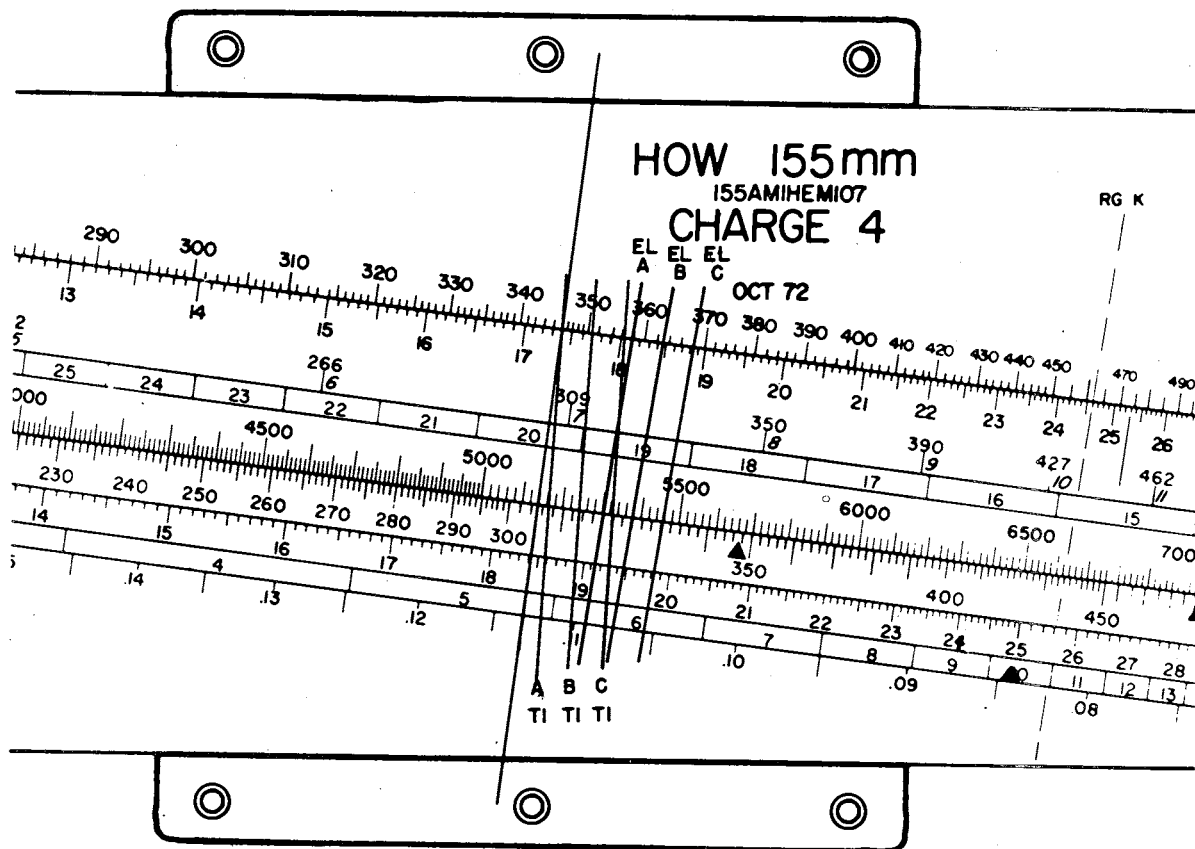
|                 |      |
|-----------------|------|
| Cht df          | 3253 |
| Adj df          | 3256 |
| Total df corr   | L3   |
| -Drift (el 324) | L7   |
| GFT df corr     | R4   |

The battalion base piece comparative VEs are A Btry +3.3 and C Btry -2.8 (fig 7-9).

| CALIBRATION DATA |         |      |    |     |  |  |  |  | BN BP COMP VE                        |                                      |                                      |
|------------------|---------|------|----|-----|--|--|--|--|--------------------------------------|--------------------------------------|--------------------------------------|
| UNIT             | TUBE NO | MVV  | BP | VE  |  |  |  |  | A                                    | B                                    | C                                    |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |
| <b>A</b>         | 511     | -1.6 | BP | 0.0 |  |  |  |  | A BTRY REGISTERED<br>TRANSFER TO B&C | B BTRY REGISTERED<br>TRANSFER TO A&C | C BTRY REGISTERED<br>TRANSFER TO A&B |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |
| <b>B</b>         | 502     | -4.9 | BP | 0.0 |  |  |  |  | 0.0                                  | +3.3                                 | +6.1                                 |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |
| <b>C</b>         | 503     | -7.7 | BP | 0.0 |  |  |  |  | -3.3                                 | 0.0                                  | +2.8                                 |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |
|                  |         |      |    |     |  |  |  |  |                                      |                                      |                                      |

Figure 7-9. Battalion base piece comparative VEs.





★ Figure 7-10. GFT with multibattery GFT settings.

The muzzle velocity unit correction factors for the base piece comparative VEs of Batteries A and C are:

Entry rg 5100 (5140 + 0 (comp rg) = 5140 ≈ 5100)

A -21.6 (Increase Column)  
C +28.0 (Decrease Column)

The MV range corrections are:

A  $(+3.3) \times (-21.6) = -71.3 \approx -70$   
C  $(-2.8) \times (+28.0) = +78.4 \approx +80$

The corrected ranges for Batteries A and C are equal to the GFT range for Battery B plus the respective range corrections:

A  $5140 + (-70) = 5070$   
C  $5140 + (+80) = 5220$

Using the GFT setting for Battery B and the corrected ranges determined for Batteries A and C, read the elevation and

fuze setting under the appropriate gageline (fig 7-10). The reason for each battery using the same range as Battery B is that Batteries A and C are assumed to have moved to B Battery's position to fire the registration. Therefore, the GFT range (CHART RG) is the same for all batteries. In conjunction with the previous assumption, each battery requires a different elevation to place the MPI on the registration point because of the difference in shooting strengths. The GFT deflection correction remains the same for each battery; however, each battery must determine its own total deflection correction.

A Tot df corr L3 (R4 + L7 (drift ~ 318) = L3)  
C Tot df corr L3 (R4 + L7 (drift ~ 333) = L3)

The GFT settings and GFT deflection corrections for all batteries are as follows:

GFT A: Chg 4, Lot XY, Rg 5140  
El 318, Ti 18.6; GFT  
df corr R4

GFT B: Chg 4, Lot XY, Rg 5140,  
El 324, Ti 18.9;  
GFT df corr R4

GFT C: Chg 4, Lot XY, Rg 5140,  
El 330, Ti 19.3;  
GFT df corr R4

## 7-11. Development of the Section Chief's Card

## SECTION CHIEF'S CARD

Chg 4 GB M109A1 No. 6

| QE      | QE corr | Ti corr |
|---------|---------|---------|
| 133-192 | +3      | +0.2    |
| 193-258 | +4      | +0.2    |
| 259-333 | +6      | +0.4    |
| 334-423 | +8      | +0.4    |
| 424-542 | +11     | +0.6    |

| Pc No 6 |                           | SECTION CHIEF'S CARD—COMPUTATION WORKSHEET |                          |                                           |                                            |                                            |                                        |            |                                                      |                                   |                                               | Chg 4GB |  |
|---------|---------------------------|--------------------------------------------|--------------------------|-------------------------------------------|--------------------------------------------|--------------------------------------------|----------------------------------------|------------|------------------------------------------------------|-----------------------------------|-----------------------------------------------|---------|--|
| ①       | ②                         | ③                                          | ④                        | ⑤                                         | ⑥                                          | ⑦                                          | ⑧                                      | ⑨          | ⑩                                                    | ⑪                                 | ⑫                                             |         |  |
| Range   | Range Bracket<br>① ± 500M | El Bracket<br>at Rg ②                      | Btry Comp<br>VE<br>④ 2.7 | MV Unit<br>Corr Fac<br>(Tbl F)<br>at Rg ① | Cal Rg<br>Corr<br>④ X ⑤<br>(Use Sign of ⑤) | DR Per<br>1st D Elev<br>(Tbl F)<br>at Rg ① | QE<br>Corr<br>⑥ ÷ ⑦<br>(Use Sign of ⑥) | Ti<br>Rg ① | Ti<br>Rg ①<br>+ or - 100<br>+100 if ⑧+<br>-100 if ⑧- | Ti<br>Change<br>Per 100M<br>⑩ - ⑨ | Ti Corr<br>⑥ = X<br>100M ⑪<br>(Use Sign of ⑧) |         |  |
| 1000 M  | 500 M                     | 1 m                                        | 0.1M/Sec                 | 0.1M                                      | 1 M                                        | 1 M/m                                      | 1 m                                    | 0.1        | 0.1                                                  | 0.1                               | 0.1                                           |         |  |
| 3000    | 2500<br>3500              | 133<br>192                                 | ④ 2.7                    | +17.2                                     | +46                                        | 17                                         | +3                                     | 10.0       | 10.4                                                 | 0.4                               | +0.2                                          |         |  |
| 4000    | 3500<br>4500              | 193<br>258                                 |                          | +22.4                                     | +60                                        | 15                                         | +4                                     | 13.7       | 14.1                                                 | 0.4                               | +0.2                                          |         |  |
| 5000    | 4500<br>5500              | 259<br>333                                 |                          | +27.5                                     | +74                                        | 13                                         | +6                                     | 17.8       | 18.3                                                 | 0.5                               | +0.4                                          |         |  |
| 6000    | 5500<br>6500              | 334<br>423                                 |                          | +32.4                                     | +87                                        | 11                                         | +8                                     | 22.4       | 22.9                                                 | 0.5                               | +0.4                                          |         |  |
| 7000    | 6500<br>7500              | 424<br>542                                 |                          | +37.2                                     | +100                                       | 9                                          | +11                                    | 27.8       | 28.4                                                 | 0.6                               | +0.6                                          |         |  |
|         |                           |                                            |                          |                                           |                                            |                                            |                                        |            |                                                      |                                   |                                               |         |  |

DA FORM 4758

1 Oct 78

FOR USE OF THIS FORM, SEE FM 6-40.  
THE PROPONENT AGENCY IS TRADOC.

Figure 7-11. Comparative VE computations.

★ *a.* In area fire, a calibration correction should be applied to any piece whose battery comparative VE varies by more than  $\pm 1.5$  meters per second from that of the base piece. Calibration corrections for the optimum range of each charge for which calibration corrections are known are computed on the Section Chief's Card—Computation Worksheet (DA Form 4758) and tabulated on a card furnished to the chief of section by the fire direction center. The chief of section extracts the appropriate corrections from the card and applies them to the announced time and quadrant for each mission fired thereafter.

*b.* The procedure for constructing a section chief's card is as follows (fig 7-11):

(1) Select the full 1000-meter ranges that fall within transfer limits for the applicable charge.

(2) Determine from table F the elevations (to the nearest mil) corresponding to ranges 500 meters greater than and 500 meters less than the center whole 1000-meter range. (For example for the center whole 1000-meter range of 4000, determine the elevations corresponding to ranges 3500 and 4500.) Express the elevations extracted toward the center of the 1000-meter bracket. This will preclude two like elevations appearing on the card.

(3) Determine from table F the MV unit correction factor for an increase (or decrease) in shooting strength from the base piece to the varying piece. If the battery comparative VE of the varying piece differs by more than +1.5 meters per second, determine the MV unit correction factor from the increase column; if it differs by more than -1.5 meters per second, determine the MV unit correction from the decrease column. The MV unit correction factor is determined at the center whole 1000-meter range.

(4) Determine the range correction by multiplying the MV unit correction factor by the battery comparative VE. The range correction is expressed to the nearest meter and takes the sign of the MV unit correction factor.

(5) Determine the change in range for a 1-mil change in elevation from table F, column 5, at the center whole 1000-meter range.

(6) Determine the QE correction to be applied by dividing the range correction by the change in range for a 1-mil change in elevation. Express the QE correction to an accuracy of 1 mil. The QE correction has the same sign as that of the MV unit correction factor.

(7) Determine the time change per 100 meters from table F, column 3, by using decreasing range if the battery comparative VE is plus and an increasing range if the battery comparative VE is minus. If the battery comparative VE is plus, subtract the fuze setting corresponding to the center whole 1000-meter range from the fuze setting corresponding to the center whole 1000-meter range minus 100 meters. If the battery comparative VE is minus, subtract the fuze setting corresponding to the center whole 1000-meter range from the fuze setting corresponding to the center whole 1000-meter range plus 100 meters.

(8) Determine the time correction by establishing the following proportion:

$$\frac{\text{Range correction (meters)}}{100 \text{ meters}} = \frac{X}{\text{Time change per 100 meters}}$$

The time correction has the same sign as the quadrant correction.

*c.* Only three of the items determined in *b* above are shown on the section chief's card: elevation brackets, QE correction, and time correction.

**Example:**

A 155-mm M109A1 howitzer battery (Btry C) has one piece (No. 6) whose battery comparative VE is greater than +1.5 meters per second. The battery comparative VE for piece number 6 is -2.7 meters per second. The FDC computes a section chief's card for charge 4 green bag as follows: (The example will explain the computations for range 3000 only.) See figure 7-11.

(1) The FDO selects the full 1000-meter ranges that fall within transfer limits for charge 4GB: 3000 meters, 4000 meters, 5000 meters, 6000 meters, 7000 meters, etc. See column (1).

(2) Using table F of the TFT, the FDO determines the elevations that correspond to the ranges 500 meters greater than and 500 meters less than the whole 1000-meter range. For the center range of 3000 meters, the range brackets are 2500 meters and 3500 meters. See column (2). The corresponding elevations are (column (3)):

EL (~2500 meters) = 133

EL (~3500 meters) = 192

(3) Record the battery comparative VE (D or I) in column (4). From table F, TFT, the muzzle velocity unit correction factor for a decrease (in this example the battery comparative VE is -2.7 m/s) in shooting strength is determined to be +17.2 m/s (using column (10), for a range of 3000 meters, table F, TFT). Record this value in column (5).

(4) The range correction is determined by multiplying +17.2 (MV unit correction factor) by -2.7 (btry comp VE)  $(17.2)(2.7) = +46$  meters. The range correction is recorded in column (6).

(5) The change in range for a 1-mil change in elevation for range 3000 meters of 17 (table F, TFT) is determined and recorded in column (7).

(6) The QE correction is determined by dividing +46 (the range correction) by 17 (change in range for 1-mil change in elevation) and is recorded in column (8).  $46 \div 17 = +3$

(7) The time change per 100 meters is determined by finding the fuze setting (column 3, table F, TFT) that corresponds to the center range and recording it in column (9). Determine the fuze setting that corresponds to the center range plus 100 meters (this example has a decrease for comparative VE) and record it in column (10). Subtract the value in column (9) from the value in column (10). Record the result in column (11).

10.4 (fuze setting 3100 meters)  
(column (10))

-10.0 (fuze setting 3000 meters)

+0.4 (column (9))

(8) Time correction is determined by the following proportion and recorded in column (12):

$$\begin{array}{rcl} +46 & (\text{Rg corr}) & = X \\ 100 & & 0.4 \text{ (time change} \\ & & \text{per 100 meters)} \end{array}$$

$$X = \frac{(46)(0.4)}{100} = .184 \approx +0.2$$

#### SECTION CHIEF'S CARD

| QE      | QE corr | Ti corr |
|---------|---------|---------|
| 133-192 | +3      | +0.2    |
| 193-258 | +4      | +0.2    |
| 259-333 | +6      | +0.4    |
| 334-423 | +8      | +0.4    |
| 424-542 | +11     | +0.6    |

Figure 7-12. Corresponding elevations.

When the FDC sends a QE to the guns, the section chief determines which elevation bracket includes the QE and applies the corresponding QE correction and, if applicable, the time correction (fig 7-12).

d. The data maintained by the chief of section can be drastically reduced by use of the modified section chief's card. For this card, data is determined for the midrange of the charge used in the calibration; therefore, one quadrant is determined and placed on the gunner's aid. The time correction must be maintained by the chief of section.

#### Example:

An M109A1 battery has calibrated with charge 4 green bag. One piece (piece 6) has a battery comparative VE greater than 1.5 meters per second. The battery commander has directed that corrections be determined for charge 4 green bag, range 5000 meters. The following data (valid only when

terrain gun position corrections are not in effect) is sent to the chief of section, piece 6. CHG 4 GB, QE CORR +6, TI CORR +0.4.

*Note.* Prior to using the modified section chief's card, the battery FDO should work out the entire section chief's card and carefully examine the quadrant and time corrections. He should advise the commander on its use based on the following consideration:

The actual corrections shown in the *full* section chief's card might be substantially different from the results obtained in using the *modified* section chief's card. Using a larger battery comparative VE than in the above example coupled with a battery that had not grouped weapons would produce corrections that would be much larger than in the example.

## Section III. FALL-OF-SHOT COMPARATIVE CALIBRATION PROCEDURES

The procedures for fall-of-shot calibration are far more complex than those for chronograph calibrations. The planning, coordination, and conduct of firing are far more detailed and require considerable supervision to insure that the exercise is conducted properly to determine valid data. The battalion S3 normally is responsible for the conduct of this exercise from conception to the final determination of data, whether comparative or absolute VEs are the desired result. Normally, eight rounds are fired per tube (two warmup, six for calibration).

### 7-12. Preliminary Considerations

Comparative calibration is based on the premise that the total effects of nonstandard conditions (except velocity deviation from standard) have equal influence on the locations of the mean points of impact. This premise assumes that the difference in range between MPIs is an indication of the difference in velocity. This assumption is valid only within certain limits. For example, it does not mean that weather conditions can be ignored. For calibration, relatively stable wind conditions must be sought and a fall-of-shot calibration, either comparative or absolute, should not be attempted during the passage of a weather front.

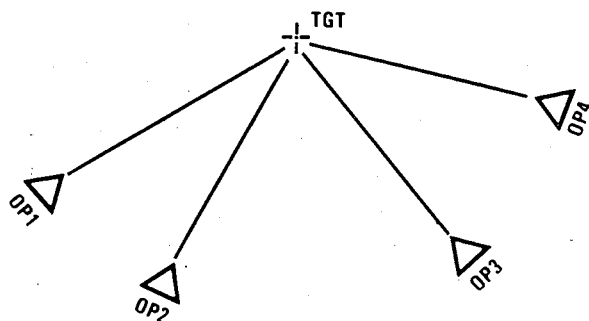
*a.* Ammunition should be prepared

sufficiently in advance of firing to insure uniform weather conditioning. Propellant temperatures of at least four rounds at each piece are measured and recorded immediately before firing.

*b.* If possible, coordination should be effected with the unit providing the required flash base from which the mean point of impact achieved by each weapon is determined. Organic observation may be used, provided the observers are trained and equipped to provide the high degree of accuracy required for fall-of-shot calibration. Four observation posts should be installed, each equipped with a battery commander's telescope (use aiming circle when BC scopes are not available) (fig 7-13). The OPs must be located by accurate survey. Each observer will record both direction and vertical angle for each round. Care must be exercised in recording so that rounds can be related to their respective pieces.

*c.* Orienting data (direction and vertical angle to the desired MPI) for each OP is determined and announced to the appropriate observer. Observers are alerted before firing is begun. For each round fired, the number of the piece firing and SHOT are announced when the piece is fired. SPLASH is announced 5 seconds before impact.

*d.* All pieces of the unit are calibrated and



EACH ROUND - DIRECTION AND VERTICAL ANGLE

Figure 7-13. Observation posts required for fall-of-shot calibration.

no special selection process is necessary. The weapons to be calibrated should be emplaced in a level position area and there should be about 2 feet between adjacent pieces. Cant must be eliminated. The weapons may be laid for direction by any of the normal methods. The target area should be level and, if at all possible, should be at about the same altitude as the position area. The weapons should be located by survey. Weapons are boresighted. Tubes must be cleaned and dried.

e. Chart data from the center of the position area to the desired point of impact is measured from a map. A common deflection and a common quadrant elevation are determined and are used for all pieces throughout the firing. Fuze quick is always used for calibration.

f. When fall-of-shot calibration is conducted, the weapon should be calibrated at a quadrant elevation between the leftmost and rightmost red-numbered elevations. A low QE minimizes the effect of nonvelocity errors absorbed into the velocity error.

g. For maximum accuracy, all personnel should be briefed on the importance of the calibration and should be instructed to exercise extreme care in the performance of their duties. A reliable system of communications and exchange of commands, data, and information should be worked out. An SOP should be developed for the conduct of firing. It is especially important that bubbles be centered exactly before each round is fired. The pieces should

be serviced and checked to insure that they are in proper working condition. A bench-checked (ordnance-tested) gunner's quadrant should be used on all pieces. At least one calibrated powder thermometer per piece should be obtained for the firing.

### 7-13. Conduct of Firing

a. Each piece is laid for quadrant elevation by use of the same gunner's quadrant. Battery right (left) is used in order to equalize the weather conditions under which each piece is fired. Sufficient time between rounds must be allowed to permit the observers to locate the round, to record the data for that round, and to change the orienting data for the next round if necessary (about 30 seconds is sufficient).

b. The first two rounds from each piece are conditioning rounds, but the observers should observe, report, and record data as a check of the system and procedures.

c. Firing should be completed as rapidly as possible. If a piece misfires, that piece is called out, the observers are notified, and firing of the other piece is continued.

d. Before the pieces are released, a check with the observers should be made to make sure that data for all rounds has been recorded and to see if any rounds were erratic or if the observers missed any rounds.

e. An erratic round can be defined as one that falls more than four range probable errors away from the mean point of impact of the rounds fired. A round that obviously does not fit the pattern of the remaining rounds should be classified as erratic and should not be included in the location of the mean point of impact. This necessitates a quick check of azimuths recorded by the two flank observers before release of a piece from the calibration site. If, for the same round, each of these observers records an azimuth quite different from that of all other rounds in the group, then an additional round should be fired from that piece. The decision to fire additional rounds is made by the officer in charge.

## 7-14. Determination of Data

*a. Determination of Range and Altitude to Mean Point of Impact for Each Piece.*

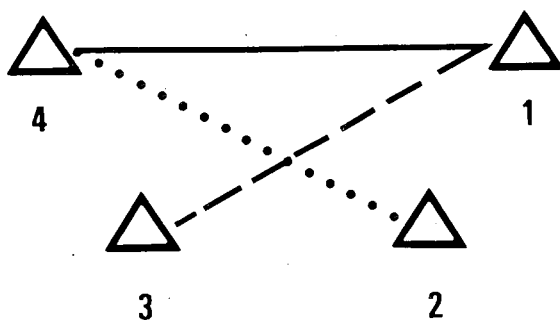
(1) When a target acquisition unit provides the flash base, it furnishes the grid coordinates and the altitude of the MPI for each piece.

(2) When the unit provides its own observation, the S3 must examine each observer's recorded data in order to detect erratic rounds and questionable observer data. After the conditioning rounds and erratic rounds have been deleted, the MPI range for each piece is determined in the following manner:

(a) Compute the average azimuth from each OP for each piece.

(b) Form three target area bases by using selected pairs of observation posts.

(c) Compute three sets of grid coordinates for each MPI, one from each of the three bases (FADAC or manual) (fig 7-14).

**BASES USED**

- OP1 & OP4  
 - - - - OP1 & OP3  
 ..... OP2 & OP4

Figure 7-14. Determination of bases.

(d) If there is an appreciable difference (20 meters or more radially) in the three sets of grid coordinates, perform a graphic check ((4) below).

(e) Average the three sets of grid coordinates to determine the MPI location.

(f) Using the grid coordinates of the piece and its respective MPI location, compute the range to the MPI for each piece.

(3) To determine the altitude of the MPI, compute the altitude of the MPI from each OP and average the four altitudes to determine the mean altitude. (If accurate maps are available, the MPI altitude can be measured on the map.)

(4) If survey, observer orientation, and observer readings are correct, all rays, as plotted from the respective OPs, will theoretically intersect at a common point. Normally, however, the rays, either for a single round or for an MPI, will not intersect but will form a polygon, referred to as the polygon of error. If the observer data appears to be of questionable accuracy, a graphical check on the magnitude and nature of the polygon of error may be performed. To accomplish the graphical check, all OPs are plotted on a gridded sheet to a scale of 1:6250 and the azimuth to the round or MPI in question is plotted as a ray from each observation post. If the graphical check indicates that only one observer is appreciably in error, his data is deleted and the data of the other three observers is used. If more than one observer is in error, then it is best to consider equally valid the data from all observers, because it is not possible to pick out the specific observers at fault. The size of the polygon of error accepted is a good measure of the accuracy of resultant range data and, hence, of the calibration itself. The smaller the polygon, the more accurate the calibration. A graphical check should be made on the common reference point before firing begins.

*b. Adjustment of Ranges for Differences in Altitude.*

(1) To obtain a valid comparison of the ranges achieved by the pieces being calibrated, all pieces should be at the same altitude. The pieces are established at the same altitude by selection of a level position area. The MPIs cannot be determined beforehand, and, although a relatively level impact area is selected, the altitudes of the MPIs may vary. Before a valid comparison

can be made of the ranges achieved by each piece, the measured ranges must be corrected to ranges that would have been achieved if all rounds had landed at a common altitude.

(2) The measured ranges are corrected for differences in the altitudes of the MPIs as follows:

(a) Select a reference altitude. Any convenient altitude may be used. The lowest MPI altitude is commonly used as a reference altitude.

(b) Subtract the reference altitude from the altitude of the mean point of impact.

(c) Multiply the difference in altitude by the cotangent of the angle of fall. (The cotangent of the angle of fall is determined from the supplementary data table (table G in the TFT) at the computed range to the MPI to the nearest 100 meters.) The product is the correction to the range. If the altitude of the MPI is greater (less) than the reference altitude, the sign of the correction is plus (minus).

(d) Add the range correction determined as in (c) above to the measured range to determine the corrected range.

#### 7-15. Determination of Battalion Comparative Velocity Error

a. In a battalion comparative calibration, the piece that achieved the longest corrected range is chosen as the standard piece. Its corrected range is the standard with which the corrected range of each of the other pieces is compared. The battalion comparative VE assigned to the standard piece is 0 meters per second.

b. The procedure for determining the battalion comparative VE is as follows:

(1) Determine the difference between the corrected range of the piece in question and the corrected range of the standard piece.

(2) Enter the basic data table (table F in the TFT) at the corrected range (to the

nearest 100 meters) of the piece in question. Determine the correction for a *decrease* in muzzle velocity of 1 meter per second.

(3) Determine an uncorrected VE by dividing the difference in range by the muzzle velocity unit correction factor. The sign of the battalion comparative VE is always minus when the longest shooting piece is the standard.

c. A valid comparative VE can be determined only if all weapons fire ammunition of the same propellant temperature. Precautions should be taken to keep all propellants at the same temperature. If there is any variation in the average propellant temperatures of the individual weapons, the VEs determined must be corrected. The final battalion VE of a particular piece is the VE that would have been attained if the ammunition fired by that weapon had the same propellant temperature as the ammunition of the standard piece. The procedure for correcting the VE for propellant temperature variation is as follows:

(1) Enter the propellant temperature tables (table E in the TFT) and determine the change to muzzle velocity for propellant temperature for each piece.

(2) Determine the correction to VE by subtracting (algebraically) the change to muzzle velocity for propellant temperature of each piece from the change to muzzle velocity propellant temperature of the standard piece.

(3) Determine the battalion comparative VEs by adding the correction to the respective VEs determined as in (2) above.

#### Example:

A 155-mm M109A1 howitzer battalion has completed firing a fall-of-shot comparative calibration with charge 7, QE 310. All pieces were at the same altitude. After the range to and altitude of each MPI have been computed, the following data is available: (Data for only four pieces is shown.)



| Piece number | Computed range (meters) | Altitude of MPI (meters) | Average propellant temperature |
|--------------|-------------------------|--------------------------|--------------------------------|
| 1            | 9665                    | 320                      | 83° F.                         |
| 2            | 9710                    | 316                      | 80° F.                         |
| 3            | 9790                    | 321                      | 80° F.                         |
| 4            | 9610                    | 325                      | 78° F.                         |

Determine the corrected ranges by correcting for differences in altitudes of mean points of impact. The lowest MPI altitude (316) is selected as the reference altitude.

| Piece number | Computed range (meters) | Alt of MPI (meters) | Difference in altitude | Cot of angle of fall | Range correction | Corrected range (meters) |
|--------------|-------------------------|---------------------|------------------------|----------------------|------------------|--------------------------|
| 1            | 9665                    | 320                 | +4                     | 2.1                  | +8               | 9673                     |
| 2            | 9710                    | 316                 | 0                      | 2.1                  | 0                | 9710                     |
| 3            | 9790                    | 321                 | +5                     | 2.1                  | +10              | 9800                     |
| 4            | 9610                    | 325                 | +9                     | 2.2                  | +20              | 9630                     |

Piece number 3 is selected as the standard piece because its corrected range (9800) is the greatest.

Determine the uncorrected VEs as follows:

| Piece number | Corrected range (meters) | Difference from std rg | MV UCF | Uncorrected VE |
|--------------|--------------------------|------------------------|--------|----------------|
| 1            | 9673                     | -127                   | +21.0  | -6.0 m/s       |
| 2            | 9710                     | -90                    | +21.0  | -4.3 m/s       |
| 3            | 9800                     | 0                      | -----  | 0 m/s          |
| 4            | 9630                     | -170                   | +20.9  | -8.1 m/s       |

Determine the battalion comparative VEs by correcting for propellant temperature (PT).

| Piece number | PT     | Change to MV for PT | Correction to VE for PT | Uncorrected VE | Battalion comparative VE |
|--------------|--------|---------------------|-------------------------|----------------|--------------------------|
| 1            | 83° F. | +1.8                | -0.4                    | -6.0           | -6.4 m/s                 |
| 2            | 80° F. | +1.4                | 0                       | -4.3           | -4.3 m/s                 |
| 3            | 80° F. | +1.4                | 0                       | 0              | 0 m/s                    |
| 4            | 78° F. | +1.1                | +0.3                    | -8.1           | -7.8 m/s                 |

## 7-16. Comparative Calibration by Battery

At times, calibration of all batteries on the same day may not be practical. In such cases, each battery conducts a separate calibration. The data from the separate calibrations is then adjusted to a common level so that the weapons can be grouped properly within the battalion.

a. The first battery to calibrate its weapons also calibrates one piece from each of the other two batteries. These pieces are later used as control pieces by their respective batteries.

b. The separate calibrations are conducted and data computed.

c. The different sets of data are adjusted to a common level by application of a correction to the VEs of the second and third batteries to calibrate. The correction to be applied to the VEs of each battery is the number of meters per second required to bring the VE of the control piece that calibrated with its own battery to the VE of the control piece when calibrated with the first battery.

### Example:

Battery A is calibrated first; Battery B, second; and Battery C, third. The VEs determined from the separate calibrations are shown in figure 7-15. A correction of +1.8 m/s must be applied to the VE for B1 obtained with Battery B to bring it to the

VE obtained with Battery A; hence, +1.8 m/s must be applied to all VEs in Battery B. Similarly, a correction of -1.2 m/s must be applied to the VE for C1 obtained with Battery C to bring it to the VE obtained with Battery A; hence -1.2 m/s must be applied to all VEs in Battery C. When the correction factors (*b* and *c* above) have been applied, the calibration data can be rewritten (adjusted to a common level) as follows:

| A      |      |
|--------|------|
| Weapon | VE   |
| A1     | 0    |
| A2     | -1.2 |
| A3     | -2.1 |
| A4     | -2.4 |
| A5     | -3.7 |
| A6     | -4.6 |

| B      |      |
|--------|------|
| Weapon | VE   |
| B1     | -0.6 |
| B2     | +0.9 |
| B3     | +1.8 |
| B4     | +0.3 |
| B5     | -0.9 |
| B6     | -1.6 |

| C      |      |
|--------|------|
| Weapon | VE   |
| C1     | -2.7 |
| C2     | -1.5 |
| C3     | -3.0 |
| C4     | -3.3 |
| C5     | -1.2 |
| C6     | -2.4 |

Figure 7-15. Calibration data.

The weapons can now be listed in order of decreasing shooting strength and the VEs adjusted so that the longest shooting weapon has a VE of 0; the correction required to bring the longest shooting piece to 0 must be applied similarly to all weapons.

The final adjusted VEs are the basis for regrouping the weapons. They represent comparative calibration VEs equal to battalion calibration VEs.

| Order of strength |                   |                   |
|-------------------|-------------------|-------------------|
|                   | First adjusted VE | Final adjusted VE |
| B3                | +1.8              | 0                 |
| B2                | +0.9              | -0.9              |
| B4                | +0.3              | -1.5              |
| A1                | 0                 | -1.8              |
| B1                | -0.6              | -2.4              |
| B5                | -0.9              | -2.7              |
| A2                | -1.2              | -3.0              |
| C5                | -1.2              | -3.0              |
| C2                | -1.5              | -3.3              |
| B6                | -1.6              | -3.4              |
| A3                | -2.1              | -3.9              |
| A4                | -2.4              | -4.2              |
| C6                | -2.4              | -4.2              |
| C1                | -2.7              | -4.5              |
| C3                | -3.0              | -4.8              |
| C4                | -3.3              | -5.1              |
| A5                | -3.7              | -5.5              |
| A6                | -4.6              | -6.4              |

## Section IV. FALL-OF-SHOT ABSOLUTE CALIBRATION PROCEDURES

### 7-17. Preliminary Considerations

The preliminary considerations for absolute calibration are the same as those for comparative calibrations except as noted in *a* through *c* below.

*a. Nonstandard Conditions.* The effects of muzzle velocity must be isolated from the effects of all other nonstandard conditions; however, certain deviations from this basic requirement are accepted in present

techniques and will be noted. Since a met must be computed, careful preparation must be made for obtaining and using met data. Coordination between the officer in charge of the calibration and the officer in charge of the met station is essential. Ideally, the met station is located at a point between the weapon and the target and at such a position that the balloon will pass as near the summit of the trajectory as possible. The time of the met message and the time of firing should be coordinated to be as close together as possible.

*b. Quadrant Elevation.* The QE fired should be such that the maximum ordinate will be equal to an altitude of a whole line number of the met message. The method of bringing an acceptable QE (240 to 460 mils) into agreement with a line number of the met message involves the use of the supplementary data table (table G) of the firing tables. The following example illustrates the method of selecting the QE to be fired in calibrating a 155-mm howitzer with charge 4 green bag:

| Altitudes of met line numbers |             |
|-------------------------------|-------------|
| Line 2                        | 500 meters  |
| Line 3                        | 1000 meters |
| Line 4                        | 1500 meters |
| Line 5                        | 2000 meters |

*Example:*

From the supplementary data table (table G, TFT), a maximum ordinate of 500 meters results in a horizontal range of approximately 5500 meters. The quadrant elevations for ranges in the vicinity of 5500 meters are in the vicinity of 334 mils, a good QE for calibration. The range corresponding to a maximum ordinate of 500 meters is 5510 meters. The corresponding QE is 334.4 mils. For convenience, this QE can be expressed to 330 mils for firing the calibration.

*c. Selection of Weapons.* It is sometimes desirable to bring only a limited number of pieces into a state of absolute calibration. Preferably, three pieces of a battalion are selected, although one is sufficient. The base

piece, if determined, or a piece with an average wear measurement within each battery should be selected. If the comparative calibration data is known or later determined, all pieces can be brought into an acceptable state of absolute calibration.

#### 7-18. Conduct of Firing

Firing absolute calibration is conducted in the same manner as that for comparative calibration except that firing by battery right (left) is not used. Each piece will complete the firing before the next piece fires.

#### 7-19. Determination of Data

*a. Total Range Correction.* The MPI for each weapon is located by the method described in comparative calibration. The developed MPI range is then computed. Site is determined by use of the difference in altitude between the piece and the mean point of impact. The computed site is subtracted from the QE fired to determine the elevation fired. The basic data table (table F) is entered and the range corresponding to the elevation is interpolated. This is the standard horizontal range that would have been achieved if all conditions had been standard at the time of firing. By subtracting the developed MPI range from the standard (firing table) range, the range correction necessary to compensate for all nonstandard conditions at the time of firing is determined.

*b. Met Range Correction.* Using the met taken at the time of firing, range corrections for all known nonstandard conditions except propellant temperature are computed. All unit corrections are determined at the entry range (nearest 100 meters) to the mean point of impact. The line number is that corresponding to the QE fired.

#### 7-20. Determination of Absolute Velocity Error

*a.* The met range correction determined by completion of the met data correction sheet is subtracted from the total range correction determined as in paragraph 7-19a. The result is the correction in meters to compensate for  $\Delta V$ . The  $\Delta V$  is then computed by dividing the

$\Delta V$  range correction by the MV unit correction (determined at MPI range). If the  $\Delta V$  range correction is plus (minus), the MV unit correction is taken from the decrease (increase) column. Absolute VE is determined by subtracting the muzzle velocity change to propellant temperature from  $\Delta V$ . The propellant temperature used is the average of all propellant temperatures recorded at the piece.

*Example (fig 7-16):*

155-mm howitzer M109A1, charge 4 green bag:

|                   |                           |
|-------------------|---------------------------|
| MPI range         | 5130 meters<br>(computed) |
| QE fired          | 330 mils                  |
| Vertical interval | +33 meters                |
| Site (GST)        | +7.3 mils                 |
| Elevation         | 322.7 mils<br>(330 - 7.3) |

|                        |         |
|------------------------|---------|
| Propellant temperature | +55° F. |
|------------------------|---------|

Standard range corresponding to elevation 322.7 mils = 5363 meters. Total range correction to compensate for all nonstandard conditions = +233 meters (5363 - 5130). Met range correction (line number corresponding to QE 330 unit corrections at range 5100) = +172 meters.

$\Delta V$  range correction = +61 meters (233 - 172)  
Unit correction for muzzle velocity (decrease) rg 5100 = +28.0

$\Delta V = +61 \div 28.0 = -2.2$  m/s (minus sign indicates a decrease in velocity)

Change to muzzle velocity for propellant temperature = -0.9

Absolute VE = -1.3 m/s (-2.2 - (-0.9))

b. In the fall-of-shot absolute calibration, the absolute VE of the standard piece can be determined in relation to the standard muzzle velocity given in the firing tables. At least one piece has to participate in both an absolute and a comparative calibration.

*Example:*

| Tube No. | Comp VE | Abs VE |
|----------|---------|--------|
| 1        | 0       | -1.3   |

|   |       |      |
|---|-------|------|
| 2 | -0.3  | -1.6 |
| 3 | -0.9* | -2.2 |
| 4 | -1.2  | -2.5 |
| 5 | -1.5  | -2.8 |
| 6 | -1.5  | -2.8 |

\*Tube 3 fires an absolute calibration and is -2.2 m/s from standard. The difference between the comparative VE and the absolute VE is -1.3 (-2.2 - (-0.9) = -1.3). This difference is applied to all comparative VEs. If more than one weapon is used when determining absolute VEs, the absolute VEs obtained are averaged and the average is applied to all comparative VEs to bring them into an absolute state.

## 7-21. Comparison of Fall-of-Shot Calibration and Chronograph Calibration Data

a. The absolute VE of -1.3 meters per second in the preceding example approximates absolute calibration for this weapon-ammunition combination. However, if such a calibration is conducted in conjunction with an ordnance chronograph calibration, the officer in charge should not be unduly alarmed if the MVV is of a different magnitude. Primary reasons for this difference are:

(1) A projectile lot that is more or less efficient in overcoming air resistance than the projectile lot used in constructing the firing tables. This may show up as an increase or a decrease in range not otherwise accounted for.

(2) Errors in the met data used.

(3) Limitations of computational procedures and firing tables.

(4) Errors in survey.

(5) Errors in the QE used (to include barrel curvature).

b. Fall-of-shot calibration data can be used to group weapons, select base piece, determine battery comparative VEs, and battalion base piece comparative VEs, and transfer GFT settings as described in section II.

## Section V. VELOCIMETER AND FADAC PROCEDURES

### ★ 7-22. Velocimeter

*a. Description.* The M90 radar chronograph (velocimeter) is a muzzle velocity measuring system designed to operate under field conditions. The velocimeter provides a readout muzzle velocity for each round fired or the average readout muzzle velocity for a number of rounds (up to eight).

*b. Muzzle Velocity Variations.* The velocimeter muzzle velocity readout is the achieved muzzle velocity extrapolated back to the muzzle. The calibrated muzzle velocity is determined by applying corrections for nonstandard powder temperature and projectile weight to the MV readout. Using the techniques shown in section II, an MVV can be computed. All other techniques from section II apply to the velocimeter.

*c. Calibration Validity.*

(1) The velocimeter can store eight muzzle velocity readings. Figure 7-16 contains the statistic data of MV validity assurance for accepted accuracies of 1 or 2 PER. A six-round calibration is desired, but a four-round sampling is acceptable. Calibration data from a sampling of fewer than four rounds is not recommended but can be used if it is the best data available.

(2) The velocimeter readouts must be inspected to determine unusable readings. The velocimeter will display an E (error indicator), which indicates only a poor/inaccurate radar return. When an error display is indicated, the velocimeter eliminates the reading from the average. The velocimeter does not check round-to-round variations for accuracy. Readings that exceed the mean by  $\pm 3.0$  m/s should be discarded. If a readout is excluded by the FDO, the average muzzle velocity readout must be manually recomputed.

*d. Calibration Processing.* The M90 worksheet (fig 7-17) and the FDC MV record form (fig 7-18) are organized to facilitate computations and record keeping. If FADAC is used for application of MV corrections, the target grid must be recorded on the worksheet.

(1) The velocimeter operator records the following information on the worksheet and forwards it to the FDC:

Administrative information  
Start and end powder temperatures  
Velocimeter readouts

(2) The FDC:

Averages the powder temperature

| NUMBER OF ROUNDS                 | 1   | 2   | 3   | 4   | 5   | 6   |
|----------------------------------|-----|-----|-----|-----|-----|-----|
| CALIBRATED MUZZLE VELOCITY 1 PER | 50% | 66% | 76% | 82% | 87% | 90% |
| CALIBRATED MUZZLE VELOCITY 2 PER | 82% | 94% | 98% | 99% | 99% | 99% |

Figure 7-16. Assurance of muzzle velocity validity.

Inspects readouts for errors  
 Determines usable rounds  
 Determines and applies MV corrections  
 Computes and records calibrated muzzle  
 velocity and battery comparative VEs  
 Gives gun sections calibrated MV to be  
 entered on DA Form 2408-4.

DA Form 4982-1 and  
 DA Form 4982  
 are available through normal  
 AG supply channels.

| M90 RADAR CHRONOGRAPH/VELOCIMETER WORKSHEET                        |                                   |                                   |                      |               |               |              |
|--------------------------------------------------------------------|-----------------------------------|-----------------------------------|----------------------|---------------|---------------|--------------|
| For use of this form, see FM 6-40; the proponent agency is TRADOC. |                                   |                                   |                      |               |               |              |
| CHARGE/ZONE<br><b>4GB</b>                                          | DATE/TIME<br><b>170830 APR 81</b> | SHELL<br><b>HE</b>                | MODEL<br><b>M107</b> |               |               |              |
| POWDER LOT<br><b>AA11-2233</b>                                     |                                   | PROJECTILE WEIGHT<br><b>5 1/4</b> |                      |               |               |              |
| ITEMS                                                              | GUN NUMBERS                       |                                   |                      |               |               |              |
|                                                                    | 1<br>6                            | 2<br>7                            | 3<br>8               | 4<br>9        | 5<br>0        | 6<br>1       |
| BUMPER NO.                                                         | <b>C-22</b>                       | <b>C-24</b>                       | <b>C-26</b>          | <b>C-28</b>   | <b>C-30</b>   | <b>C-32</b>  |
| TUBE NO.                                                           | <b>1022</b>                       | <b>2034</b>                       | <b>4236</b>          | <b>1122</b>   | <b>3030</b>   | <b>2323</b>  |
| STARTING POWDER TEMPERATURE                                        | <b>+64</b>                        | <b>+66</b>                        | <b>+68</b>           | <b>+70</b>    | <b>+74</b>    | <b>+72</b>   |
| ENDING POWDER TEMPERATURE                                          | <b>+68</b>                        | <b>+70</b>                        | <b>+70</b>           | <b>+72</b>    | <b>+74</b>    | <b>+76</b>   |
| *AVERAGE POWDER TEMPERATURE                                        | <b>+66</b>                        | <b>+68</b>                        | <b>+69</b>           | <b>+71</b>    | <b>+74</b>    | <b>+74</b>   |
| M90 READOUT                                                        |                                   |                                   |                      |               |               |              |
| ROUND NO. 1                                                        | <b>320.1</b>                      | <b>320.6</b>                      | <b>319.4</b>         | <b>319.0</b>  | <b>320.6</b>  | <b>320.9</b> |
| ROUND NO. 2                                                        | <b>319.7</b>                      | <b>320.9</b>                      | <b>319.7</b>         | <b>319.4</b>  | <b>320.1</b>  | <b>320.7</b> |
| ROUND NO. 3                                                        | <b>319.9</b>                      | <b>321.1</b>                      | <b>319.9</b>         | <b>319.5</b>  | <b>320.5</b>  | <b>320.6</b> |
| ROUND NO. 4                                                        | <b>319.4</b>                      | <b>320.8</b>                      | <b>319.8</b>         | <b>319.3</b>  | <b>321.0</b>  | <b>321.4</b> |
| ROUND NO. 5                                                        | <b>323.6E</b>                     | <b>321.0</b>                      | <b>319.6</b>         | <b>319.9</b>  | <b>321.0</b>  | <b>321.4</b> |
| ROUND NO. 6                                                        | <b>320.2</b>                      | <b>316.4E</b>                     | <b>319.1</b>         | <b>319.0</b>  | <b>320.8</b>  | <b>320.9</b> |
| ROUND NO. 7                                                        | <b>320.0</b>                      | <b>320.7</b>                      | <b>327.8E</b>        | <b>319.6</b>  | <b>329.0E</b> | <b>320.8</b> |
| ROUND NO. 8                                                        | <b>315.1E</b>                     | <b>320.8</b>                      | <b>319.9</b>         | <b>328.1E</b> | <b>320.9</b>  | <b>321.3</b> |
| READOUT AVERAGE                                                    | <b>319.9</b>                      | <b>320.8</b>                      | <b>319.6</b>         | <b>319.4</b>  | <b>320.7</b>  | <b>321.0</b> |
| *MUZZLE VELOCITY (MV) CORRECTION<br>FOR NONSTANDARD CONDITIONS     | <b>+1.9</b>                       | <b>+1.8</b>                       | <b>+1.8</b>          | <b>+1.6</b>   | <b>+1.5</b>   | <b>+1.5</b>  |
| *CALIBRATED MUZZLE VELOCITY (MV)                                   | <b>321.8</b>                      | <b>322.6</b>                      | <b>321.4</b>         | <b>321.0</b>  | <b>322.2</b>  | <b>322.5</b> |
| NO. WARMUP ROUNDS FIRED                                            | <b>0</b>                          | <b>0</b>                          | <b>0</b>             | <b>0</b>      | <b>0</b>      | <b>0</b>     |
| REMARKS                                                            |                                   |                                   |                      |               |               |              |

\*Determined by the Fire Direction Center

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MAY 81

Figure 7-17. M90 Worksheet.

| MUZZLE VELOCITY RECORD                                             |               |                       |                      |                    |       |       |
|--------------------------------------------------------------------|---------------|-----------------------|----------------------|--------------------|-------|-------|
| For use of this form, see FM 6-40; the proponent agency is TRADOC. |               |                       |                      |                    |       |       |
| 1ST LOT CALIBRATION                                                | CHARGE/ZONE   | DATE                  | PROJECTILE FAMILY    | 1ST POWDER LOT NO. |       |       |
|                                                                    | 4GB           | 170830 APR 81         | HE                   | AA 11-2233         |       |       |
| ITEMS                                                              | GUN NUMBERS   |                       |                      |                    |       |       |
|                                                                    | 1             | 2                     | 3                    | 4                  | 5     | 6     |
| WEAPON BUMPER NO.                                                  | C-22          | C-24                  | C-26                 | C-28               | C-30  | C-32  |
| WEAPON TUBE NO.                                                    | 1022          | 2034                  | 4236                 | 1122               | 3030  | 2323  |
| STANDARD MUZZLE VELOCITY                                           | 318.5         | 318.5                 | 318.5                | 318.5              | 318.5 | 318.5 |
| CALIBRATED MUZZLE VELOCITY                                         | 321.8         | 322.6                 | 321.4                | 321.0              | 322.2 | 322.5 |
| MUZZLE VELOCITY VARIATION (MVV)                                    | +3.3          | +4.1                  | +2.9                 | +2.5               | +3.7  | +4.0  |
| MVV OF BASE PIECE (-)                                              | +3.3          | +3.3                  | +3.3                 | +3.3               | +3.3  | +3.3  |
| BATTERY COMPARATIVE VE (+)                                         | 0             | +0.8                  | -0.4                 | -0.8               | +0.4  | +0.7  |
| 2D LOT CALIBRATION                                                 | DATE          | 1ST LOT BASE PIECE MV | 2D LOT BASE PIECE MV | 2D POWDER LOT NO.  |       |       |
|                                                                    | 171300 APR 81 | 321.8                 | 322.3                | BB22-3344          |       |       |
| ITEMS                                                              | GUN NUMBERS   |                       |                      |                    |       |       |
|                                                                    | 1             | 2                     | 3                    | 4                  | 5     | 6     |
| DIFFERENCE IN MUZZLE VELOCITY (MV)                                 | +0.5          | +0.5                  | +0.5                 | +0.5               | +0.5  | +0.5  |
| 1ST LOT CALIBRATION MV                                             | 321.8         | 322.6                 | 321.4                | 321.0              | 322.2 | 322.5 |
| 2D LOT MV                                                          | 322.3         | 323.1                 | 321.9                | 321.5              | 322.7 | 323.0 |
| REMARKS                                                            |               |                       |                      |                    |       |       |

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\*Btry comparative VE does not change until all weapons are recalibrated.

Figure 7-18. FDC MV record.

e. **FDC Record Keeping.** The velocimeter provides the field artillery with current,

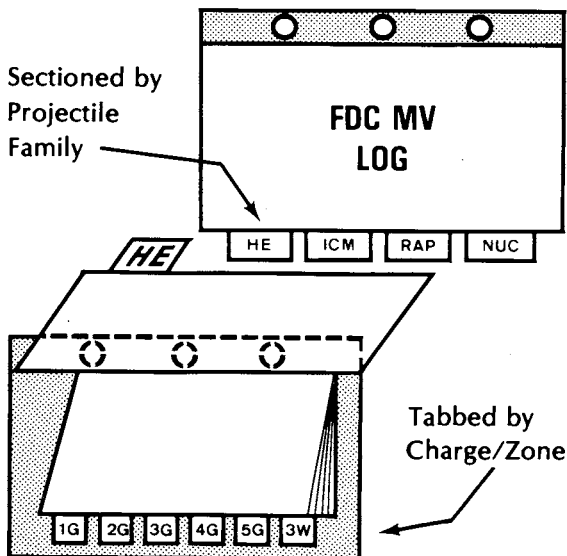


Figure 7-19. Suggested FDC MV log.

accurate, and readily available muzzle velocities. This increased MV availability challenges the FDC's record keeping ability. Figure 7-19 is a suggested format for a permanent muzzle velocity record form. This form is used in conjunction with the velocimeter worksheet. Muzzle velocities and battery comparative VEs must be maintained by charge, powder lot, and projectile family.

### 7-23. FADAC

FADAC will compensate for nonstandard muzzle velocities. The chronograph reduction routine on matrix 2 can be used to reduce chronograph data to a muzzle velocity. This MV can then be entered for each firing unit. When the firing unit represents a battery, the base piece muzzle velocity is usually used. Average muzzle velocities may be used when platoons are entered as firing units.

## CHAPTER 8

# TERRAIN GUN POSITION CORRECTIONS/SPECIAL CORRECTIONS

### Section I. INTRODUCTION

To enhance unit survivability on the battlefield, a unit must take maximum advantage of the natural cover and concealment offered by the terrain and vegetation (fig 8-1). When pieces are so positioned, corrections may be required to obtain an acceptable burst pattern (sheaf) in the target area. These corrections should compensate for the differences in muzzle velocity between pieces as well as terrain positioning of the weapons. When fire for effect rounds impact in the target area, the results will, to a large extent, depend on how well the sheaf fits the size and shape of the target.



Figure 8-1. Terrain positioning.



### 8-1. Types of Corrections

Artillery fires can be computed to fit the size and shape of the target by computation of corrections for:

**TERRAIN POSITIONING  
SHOOTING STRENGTH  
IRREGULARLY SHAPED TARGETS**

a. Terrain gun position corrections are precomputed individual piece corrections applied to the gunner's aid on the panoramic telescope and the correction counter on the range quadrant of each piece. Terrain gun position corrections are computed by the advance party personnel or the battery FDC.

b. Special corrections are individual piece corrections applied to time (ti), deflection (df), and quadrant elevation to place the FFE bursts in a precise pattern on the target. Special corrections may be computed by the battalion or battery FDC.

c. Special corrections and TGPC include corrections for the location of each weapon in the battery area (position corrections) and for the shooting strength of each weapon (calibration corrections).

TGPC goal = Acceptable sheaf in target area

Special corrections goal = Sheaf tailored to fit the target

### 8-2. Piece Displacement

a. To determine position corrections, the relative position of pieces in the battery area must be known (piece displacement). Piece displacement is the number of meters the piece is forward or behind and right or left of battery center. It is measured on a line parallel (forward or behind) and perpendicular to (right or left) the azimuth of fire (fig 8-2).

b. Piece displacement can be determined by estimation, pacing, or hasty traverse. Usually, estimation and pacing are not accurate enough for the large distances

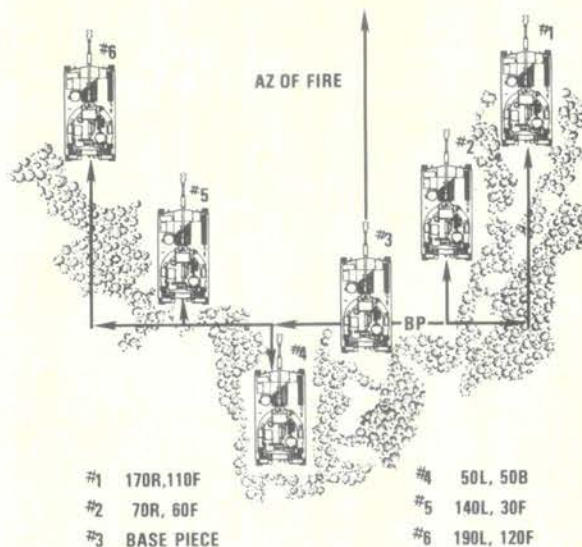


Figure 8-2. Piece displacement.

encountered in terrain positioning. The hasty traverse technique is a quick, accurate means of determining piece displacement using the M10/M17 plotting board.

### 8-3. Sheafs

a. A target is covered by fire by controlling the pattern of bursts (sheaf) on the target.

b. When the battery fires a parallel sheaf, the rounds impact at the target in generally the same pattern as formed by the pieces in the battery area. The width and depth of the battery sheaf are always measured on a line perpendicular to the line of fire. As the line of fire changes, so do the width and depth of the battery sheaf (fig 8-3).

c. The width of a sheaf is the lateral distance between the center of the flank bursts. The sheaf front is the width plus one effective burst width. The depth of the sheaf is the lateral distance between the center of the foremost and rearmost bursts.

d. There are five types of sheafs that may be obtained with TGPC and special corrections.

(1) *Parallel sheaf.* All weapons fire the same deflection and quadrant elevation.

(2) *Converged sheaf.* All weapons fire



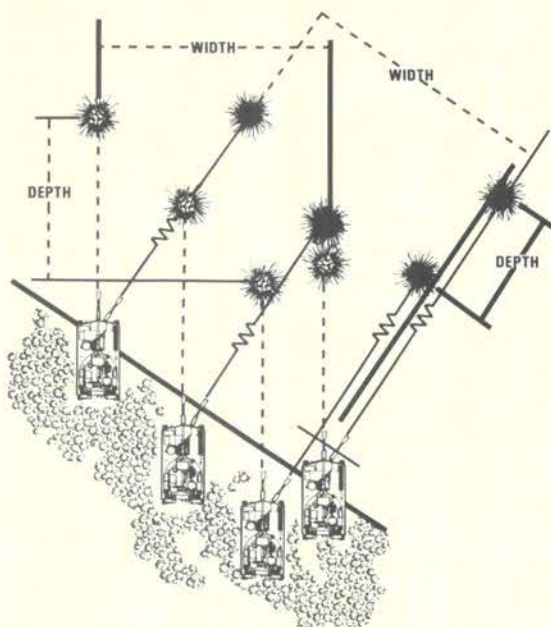


Figure 8-3. Changes in sheaf caused by a change in the line of fire.

different deflections and quadrant elevations to hit the same point.

(3) *Open sheaf.* All weapons may fire different deflections and quadrant elevations to achieve a lateral distance between the centers of two adjacent bursts equal to one effective burst width (fig 8-4).

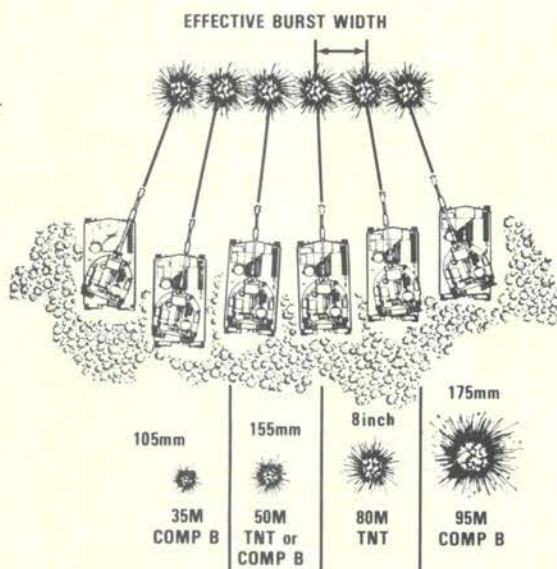


Figure 8-4. Open sheaf.

Table 8-1. Sheaf Widths

| <u>CALIBER</u> | <u>OPEN</u><br><u>SHEAFS</u><br><u>(METERS)</u> | <u>STANDARD</u><br><u>SHEAFS</u><br><u>(METERS)</u> |
|----------------|-------------------------------------------------|-----------------------------------------------------|
|                | <u>WIDTHS</u>                                   | <u>WIDTHS</u>                                       |
| 105mm          | 150                                             | 100                                                 |
| 155mm          | 250                                             | 200                                                 |
| 8-inch         | 240                                             | 180                                                 |
| 175mm          | 285                                             | 180                                                 |

(4) *Standard sheafs.* Standard sheafs are used when computing TGPC. The widths of standard sheafs are smaller than open sheafs to compensate for the expansion of the sheaf as the battery fires at greater ranges than the center range of the TGPC sector. Standard sheafs will be explained further in section III. The comparison of standard and open sheafs are shown in table 8-1.

(5) *Special sheafs.* Special sheafs are any type of sheaf other than parallel, converged, open, or standard, and must be specified (e.g., Sheaf 80 meters  $\times$  130 meters, attitude 800) (fig 8-5).

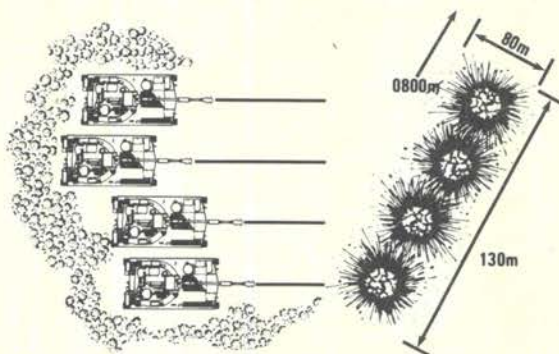


Figure 8-5. Special sheaf.

## Section II. HASTY TRAVERSE

There are three techniques for determining piece displacement: estimation, pacing, and hasty traverse. The estimation technique is the least desirable method. Using this technique, the battery commander or executive officer estimates the displacement of the pieces about battery center (BC) and perpendicular to the azimuth of lay. The pacing technique provides fair accuracy in small open areas but is time consuming. Using this technique, the battery commander or executive officer determines displacement by pacing from BC parallel and perpendicular to the azimuth of lay. The hasty traverse technique is a rapid and accurate technique for determining piece displacement. This technique is a graphic solution of piece displacement that uses the M10/17 plotting board.

### 8-4. M10/17 Plotting Board

The M10/17 plotting board is used to compute TGPC and special corrections.

a. The plotting board consists of three basic parts: gridded base, clear disk, and screw or rivet.

(1) *Gridded base.* The gridded base (fig 8-6) normally represents the target area. The small red squares may be assigned any value depending upon the intended use.

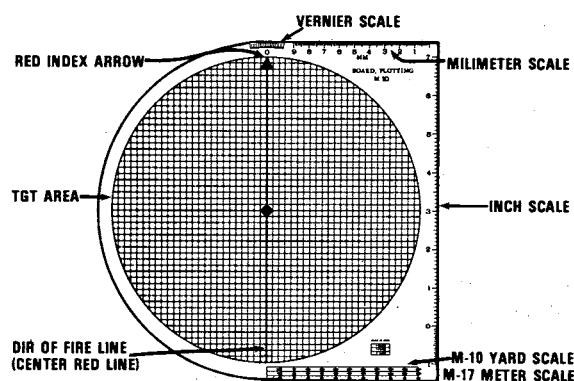


Figure 8-6. Gridded base.

|                                   |            |
|-----------------------------------|------------|
| Terrain gun position corrections. | 10 meters  |
| Special corrections .....         | 10 meters  |
| Emergency FDC .....               | 20 meters  |
| Laser hasty adjustment .....      | 200 meters |

The red arrow on the base represents the direction of fire. The vernier scale at the top center allows reading azimuth or deflection to the nearest mil (it is not normally used; values to the nearest mil are visually interpolated). Other scales found on the base are a millimeter scale (top) and an inch scale (right side). On the bottom is a scale in meters on the M17 and in yards on the M10 for scaling distances from maps.

(2) *Clear disk.* The clear disk (fig 8-7) normally represents the battery position and has three scales around the outside edge.

★ (a) The outermost black scale is used for azimuths or lay deflections. It is graduated every 10 mils and numbered every 100 mils from 0 to 6300. This scale is used for hasty traverse, when computing TGPC, when the plotting board is used as an emergency FDC, and when the plotting board is used for laser hasty adjustment and angles.

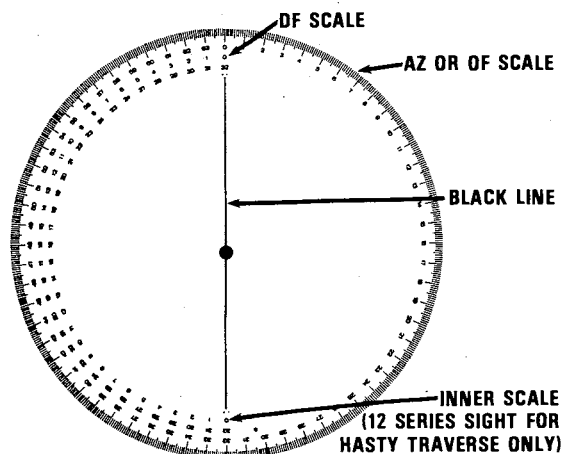


Figure 8-7. Clear disk.

- ★ (b) The red scale is a deflection scale and is used when computing special corrections and TGPCs.

(c) The inner black scale is used primarily for the M12 series sight for hasty traverse. It can also be used to measure angles in the vertical plane.

(3) *Screw or rivet.* The screw or rivet is used to hold the disk to the base and may be used to represent one of the following:

BATTERY CENTER  
THE TARGET  
LOCATION OF THE LAST BURST

b. A memory aid for hasty traverse (for the M12 series sight) is shown in figure 8-8.

### 8-5. Piece Displacement, Deflection, and Distance

a. The data required to determine displacement using the hasty traverse technique are:

Final deflection announced in laying each piece.

Distance from each piece to the aiming circle.

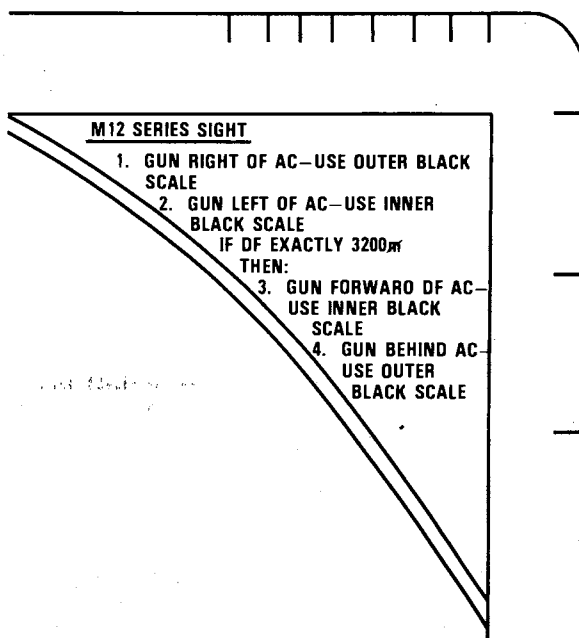


Figure 8-8. Memory aid for hasty traverse.

For the M12 series sight, the FDC needs to know the relationship of each piece to the aiming circle (AC) in relation to the azimuth of lay (i.e., left/right or if deflection is exactly 3200 mils forward/behind). This may be sent to the FDC in either of two formats.

Rough sketch of the battery to include AC and all weapons plotted in relationship to the azimuth of lay

or

When weapon deflection and distance is sent to the FDC, include if weapon is left/right or when deflection is exactly 3200 forward/ behind AC (e.g., No. 1 df 2660 mils L 40 meters, No. 2 df 3200 mils B 70 meters).

b. The deflections that are used to plot weapons on the M10/17 plotting board are the final deflections announced in laying each piece. The executive officer or chief of firing battery, when laying the weapons, should record the final deflections announced to each piece. These deflections and the distance from each piece to the AC are reported to the FDC.

c. The distance from each piece to the AC can be determined by the following methods:

(1) *Straight-line pacing.* Each section provides a man with a known pace, to pace the distance from his weapon to the AC. He may be guided on a straight line by the gunner sighting through his panoramic telescope.

(2) *Subtense.* When using subtense for TGPC computations, the 2-meter rod (subtense bar) is used. Distances up to 250 meters can be measured to within a fraction of a meter using this technique. For details on the use of the subtense bar and the subtense table, refer to FM 6-50.

### 8-6. Hasty Traverse Using M100 and M12 Series Sights

Hasty traverse uses the final lay deflections and distances from BP to the AC and from the AC to all other pieces to graphically represent

piece displacement on the M10/17 plotting board. All deflections are set over the red index arrow (top center of gridded base) (fig 8-9). The distance to the aiming circle is marked

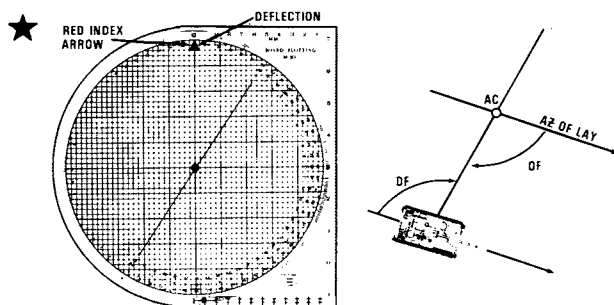


Figure 8-9. Deflection from AC to No.4 on M10/17 plotting board.

off up from the base piece toward the red index arrow along the red center line (fig 8-10). Distances for all other weapons are marked

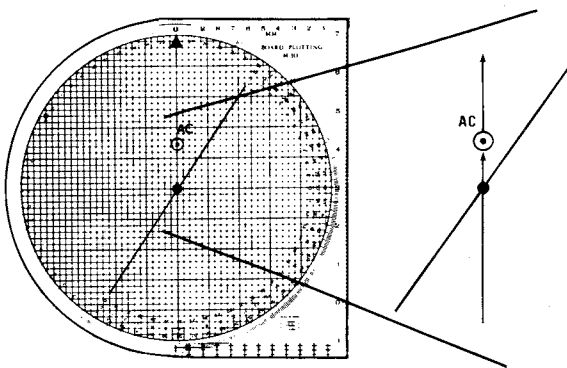


Figure 8-10. Marking off AC distance.

off down from the AC, parallel to the red center line (fig 8-11).

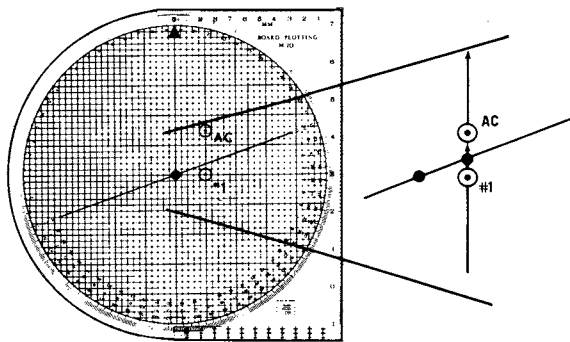


Figure 8-11. Marking off weapon distance.

**Mark weapon distance down from AC,  
parallel to red center line.**

*a. M100 Series Sight.*

(1) The center of the plotting board represents battery center which, by definition, is the location of the base piece. First, the AC should be plotted in relation to the base piece, then all other weapons can be plotted in relation to the AC.

(2) To plot the AC, place the deflection from the AC to the base piece over the red index arrow (use outer black scale, 0 through 6300, for the M100 series sight). Measure the distance off along the red line up toward the red index arrow. Place a dot and circle it. Label the dot "AC" for aiming circle.

(3) To plot the weapons, place the deflection over the red index arrow (outer black scale for M100 series sight). Measure off the distance down from the AC, parallel to the red center line. Place a dot and circle it. Continue this procedure for all other weapons. Label dots "1," "2," etc.

(4) To read piece displacement, rotate the 3200 (outer scale) over the red index arrow and read piece displacement left/right and forward/behind of BP (center of plotting board). See example in paragraph 8-11.

## FOR M100 SERIES SIGHT

**Use outer black scale in all cases**

*b. M12 Series Sight.*

(1) The center of the plotting board represents battery center which, by definition, is the location of the base piece. First, the AC should be plotted in relation to the base piece, then all other weapons can be plotted in relation to the AC.

(2) To plot the AC, place the deflection from the AC to the base piece (BP) over the red index arrow (use the outer black scale when the weapon is to the right of the AC in relation to the 0-3200 line on the outer scale, and the inner black scale when the weapon is to the left of the AC). Measure the distance along the red line up toward the red index arrow. Place a dot and circle it. Label the dot "AC."

(3) To plot the weapons, place the deflection over the red index arrow (outer black scale when the weapon is to the right of the AC in relation to the 0-3200 line on the outer scale, and the inner black scale when the weapon is to the left of the AC). Measure the distance down from the AC, parallel to the red center line. Place a dot and circle it. Continue this procedure for all other weapons. Label dots "1," "2," etc.

(4) To read piece displacement, rotate 3200 (outer scale) over the red index arrow and read piece displacement left/right and forward/behind of BP (center of plotting board).

(5) If the deflection from the AC to any weapon is exactly 3200, then the following rule applies: If the weapon is behind the AC, use the outer black scale; if the weapon is forward of the AC, use the inner black scale. See examples in paragraph 8-7.

#### FOR M12 SERIES SIGHT

Use outer black scale

Weapon right of AC

Weapon behind AC when df is 3200  
mils

Use inner black scale

Weapon left of AC

Weapon forward of AC when df is 3200  
mils

#### 8-7. Hasty Traverse Using Two Aiming Circles

When occupying widely dispersed position areas, two ACs may be required to lay the battery. One of the two situations must exist to use hasty traverse with two ACs.

a. One weapon (preferably the base piece) must be visible from both ACs. After plotting the first AC, as outlined in paragraph 8-6, use the same procedures to plot the second AC. Each weapon will then be plotted, on the plotting board, from the respective AC from which it was laid.

b. The two ACs must be visible to each other. If this is the case, plot the first AC as in paragraph 8-6. To plot the second AC, rotate the deflection from AC 1 to AC 2, over the red index arrow. Mark off the distance, parallel to the red center line, down from AC 1. Place a circled dot and label it "AC 2." Each weapon will then be plotted, on the plotting board, from the respective AC from which it was laid.

#### Example 1, M100 series sight:

(1) Given:

(a) 8-inch howitzer M110 battery.

(b) AC to:

|    | Deflection | Distance   |
|----|------------|------------|
| BP | 0420 mils  | 100 meters |
| 1  | 0768 mils  | 205 meters |
| 3  | 5850 mils  | 115 meters |
| 4  | 5215 mils  | 155 meters |

(2) Required:

Piece displacement for all weapons.

(3) Solution:

(a) Center of plotting board is BP.

(b) Rotate 0420, lay df from AC to BP, (outer black scale) over the red index arrow.

(c) Count off 100 meters, along the red center line, up toward the red index arrow. Place a circled dot and label it "AC" (fig 8-12).

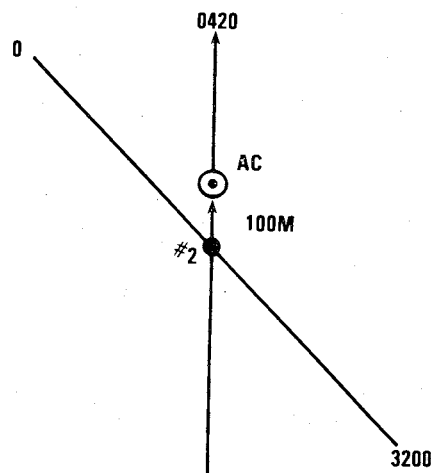


Figure 8-12. Plotting the aiming circle.

(d) Rotate 0768, lay df from AC to 1, over the red index arrow.

(e) Count off 205 meters, parallel to the red center line, *down* from the AC. Place a circled dot and label it "1" (fig 8-13).

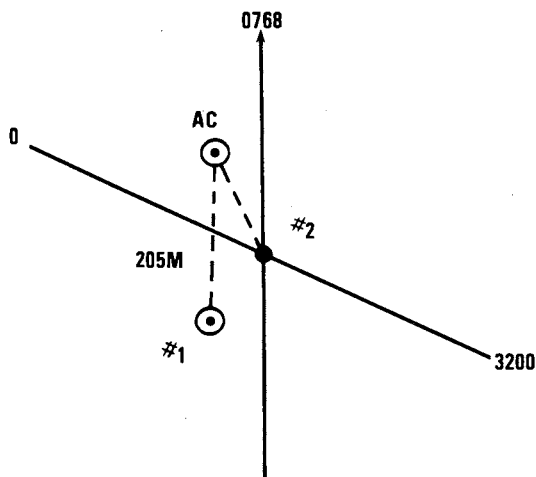


Figure 8-13. Plotting No. 1.

(f) Rotate 5850, lay df from AC to 3, over the red index arrow.

(g) Count off 115 meters, parallel to the red center line, *down* from the AC. Place a circled dot and label it "3."

(h) Rotate 5215, lay df from AC to 4, over the red index arrow.

(i) Count off 155 meters, parallel to the red center line, *down* from the AC. Place a circled dot and label it "4" (fig 8-14).

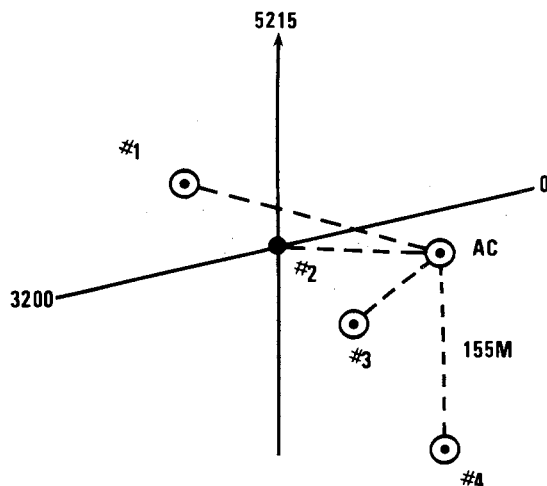


Figure 8-14. Plotting No. 4.

(j) Rotate 3200 over red index arrow and read displacement right/left and forward/behind base piece (fig 8-15).

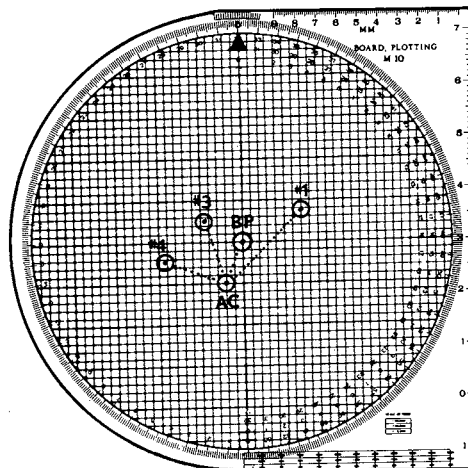


Figure 8-15. Battery sketch on plotting board.

#### (4) Answers:

| Piece  | Displacement |
|--------|--------------|
| 1      | 100R 60F     |
| 2 (BP) | BTRY CEN     |
| 3      | 100L 5F      |
| 4      | 180L 30B     |

#### Example 2, M12 series sight:

##### (1) Given:

(a) 105-mm howitzer M101A1 battery.

(b) AC to:

BP - 2610 mils R 110 meters

1 - 1840 mils R 215 meters

2 - 2128 mils R 160 meters

4 - 0493 mils L 65 meters

5 - 0945 mils L 105 meters

6 - 1485 mils L 160 meters

##### (2) Required:

Piece displacement for all weapons.

##### (3) Solution:

(a) Center of plotting board is base piece.

(b) Rotate 2610, lay df from AC to BP, (outer black scale) over the red index arrow.

(c) Count off 110 meters, along the red center line, up toward the red index arrow. Place a circled dot and label it "AC."

(d) Rotate 1840, lay df from AC to 1, (outer black scale) over the red index arrow.

(e) Count off 215 meters, parallel to red center line, down from AC. Place a circled dot and label it "1."

(f) Rotate 2128, lay df from AC to 2, (outer black scale) over the red index arrow.

(g) Count off 160 meters, parallel to the red center line, down from the AC. Place a circled dot and label it "2."

(h) Rotate 0493, lay df from AC to 4, (inner black scale) over the red index arrow.

(i) Count off 65 meters, parallel to the red center line, down from the AC. Place a circled dot and label it "4."

(j) Rotate 0945, lay df from AC to 5, (inner black scale) over the red index arrow.

(k) Count off 105 meters, parallel to the red center line, down from the AC. Place a circled dot and label it "5."

(l) Rotate 1485, lay df from AC to 6, (inner black scale) over the red index arrow.

(m) Count off 160 meters, parallel to the

red center line, down from the AC. Place a circled dot and label it "6."

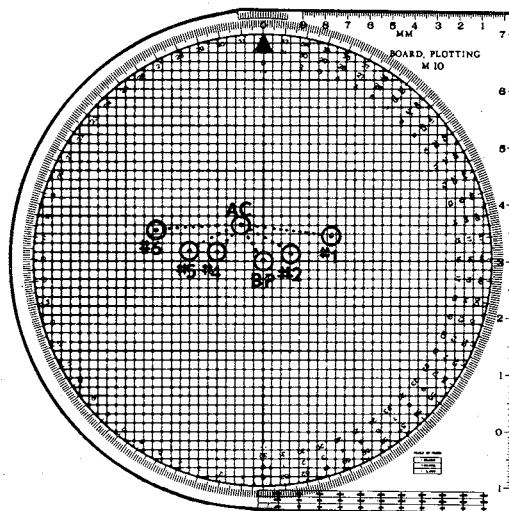


Figure 8-16. Battery sketch on plotting board.

(n) Rotate 3200 (outer black scale) over the red index arrow and read displacement right/left and forward/behind base piece (fig 8-16).

(3) Answers:

| Piece  | Displacement |
|--------|--------------|
| 1      | 150 R 40F    |
| 2      | 75 R 15F     |
| 3 (BP) | BTRY CEN     |
| 4      | 90 L 35F     |
| 5      | 140 L 30F    |
| 6      | 220 L 75F    |



## Section III. TERRAIN GUN POSITION CORRECTIONS

Terrain gun position corrections are the precomputed corrections carried on the guns to compensate for terrain positioning and muzzle velocity differences to achieve acceptable results in the target area. When TGPC are used, trajectories will often cross (fig 8-17). Generally, TGPC should be computed and applied whenever the battery occupies a position the size of which is wider than the weapon system sheaf width and/or deeper than can be corrected for by the positioning of weapons by shooting strength. Any time a position area of this type is occupied, TGPC will improve the sheaf.

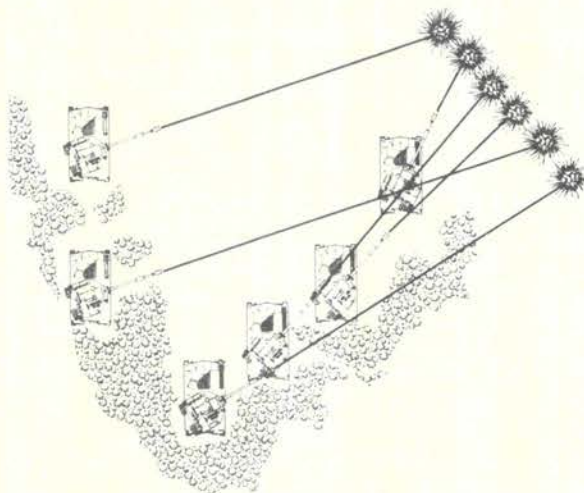


Figure 8-17. Crossing trajectories.

### 8-8. Transfer Limits and Sectors of Fire

a. Terrain gun position corrections are most accurate at the range and direction for which they were computed. They are considered valid 2000 meters over and short of the center range and 400 mils right and left of the center azimuth of the sector (fig 8-18).

b. Terrain gun position corrections will provide an acceptable effect on the target

provided the battery position is within a box 400 meters wide and 200 meters deep. This

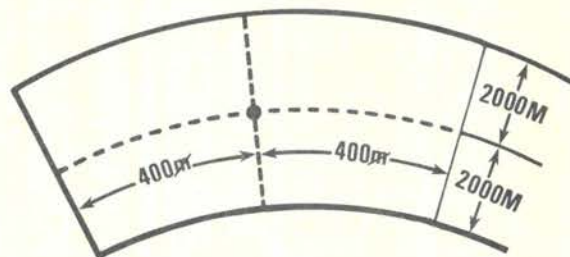


Figure 8-18. Transfer limits.

box is centered over the battery center and oriented perpendicular to the azimuth of lay. If the battery is spread out more than 400 meters by 200 meters, a degradation in effectiveness of sheafs can be expected as fires are shifted throughout the sector away from the battery center.

c. Since a battery's area of responsibility may cover an area larger than the TGPC transfer limits, the battery should compute TGPC for three sectors. Ranges to the centers of the three sectors may be different. Overlapping sectors for different charges may be necessary (fig 8-19).

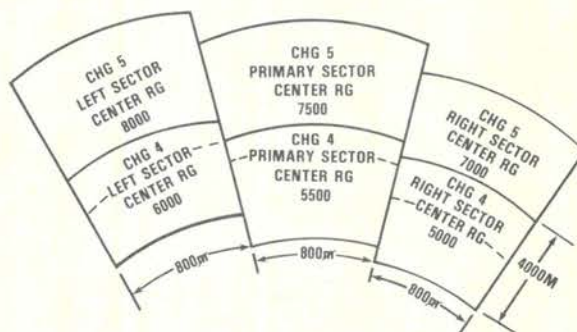


Figure 8-19. Three sectors/different ranges and overlapping sectors for different charges.

|                       |          |          |             |                          |  |     |  |             |  |                      |  |    |  |
|-----------------------|----------|----------|-------------|--------------------------|--|-----|--|-------------|--|----------------------|--|----|--|
| FIRE ORDER            |          |          |             |                          |  |     |  |             |  | Df Corr              |  | Si |  |
| INITIAL FIRE COMMANDS |          |          |             | FM MF BTRY ADJ           |  | Rg  |  | Cht Df      |  | EI                   |  |    |  |
| Sp Instr RIGHT SECTOR |          |          |             | Sh                       |  | Lot |  | Chg 4 Fz Ti |  | Df 2647 OE 328       |  |    |  |
| MTO                   |          |          |             | X T                      |  | PER |  | TF          |  | ④ VT in Eff Ammo Exp |  |    |  |
| Tgt                   | Location | Priority | Firing Unit | SUBSEQUENT FIRE COMMANDS |  |     |  |             |  |                      |  |    |  |

Figure 8-20. Right sector fire command.

### 8-9. The Fire Order

a. The fire direction officer must establish standards that indicate the corrections for the *primary* sector are standard. This is done in the "distribution" section of the fire order standards.

b. Unit SOP should direct that the primary TGPC sector is used unless otherwise indicated. The "special instructions" block of the fire command standards form will indicate which TGPC sector will be used for a mission if other than the primary sector. The absence of any instructions in the initial fire commands indicates that corrections for the primary sector will be fired. The command **LEFT (RIGHT) SECTOR** in the "special instructions" block of the initial fire commands indicates that the corrections for the left (right) sector are to be set on the guns. The command **CANCEL TERRAIN CORRECTIONS** indicates that all TGPC corrections are to be zeroed for the mission (fig 8-20).

### 8-10. Preparing the Plotting Board

a. To prepare the plotting board for use in TGPC, remove the clear disk. Use the center of the base as battery center and draw vertical burst lines corresponding to the standard sheaf for the applicable caliber weapon (fig 8-21). Refer to table 8-2 for the desired location of each burst line for a standard sheaf by caliber.

b. Construct burst lines for an open sheaf. the burst lines on the base may be color coded to eliminate confusion during the use of the plotting board. The numbering of the red-numbered scale on the disk should be extended. For the M100 series, extend to 64; for the M12 series, extend to 32.

### 8-11. Determination of TGPC

a. Piece displacement for individual weapons should be plotted from hasty traverse. If they are not and piece displacement relative to the azimuth of lay is

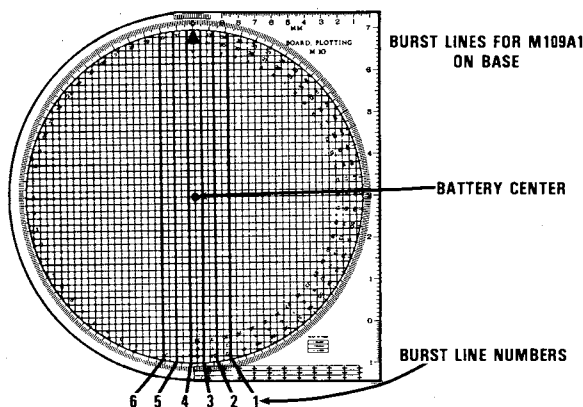


Figure 8-21. Burst lines on base.

Table 8-2. Burst Line Locations

| BURST LINE | DESIRED DISTANCE FROM BATTERY CENTER |     |     |     |     |      |
|------------|--------------------------------------|-----|-----|-----|-----|------|
|            | NUMBERS                              |     |     |     |     |      |
|            | 6                                    | 5   | 4   | 3   | 2   | 1    |
| 105 BTRY   | 50L                                  | 30L | 10L | 10R | 30R | 50R  |
| 155 BTRY   | 100L                                 | 60L | 20L | 20R | 60R | 100R |
| 8" BTRY    |                                      |     | 90L | 30L | 30R | 90R  |
| 175 BTRY   |                                      |     | 90L | 30L | 30R | 90R  |

# C1, FM 6-40

known, the following method is used to plot the weapons on the plotting board.

- ★ (1) Rotate 3200 (*inner red scale*) over red index arrow.

(2) Plot weapons right/left and forward/behind of battery center.

b. After piece displacement (for a given azimuth) has been determined, corrections for a TGPC sector are computed on the Registration/Special Correction Worksheet. TGPC computations are presented in a step-by-step format. The data required for the computations are:

Piece displacement

Center range to each sector

Charge to be fired

Battery comparative VEs

## Example:

A 155-mm M109A1 battery is laid on azimuth of 5360 mils. The center range is 5500 meters. The BP (3) is over battery center. The information shown below is available in the FDC. CHG 4 GB will be used.

## Piece Displacement Relative to Battery the Azimuth of Lay Comparative VEs

|   |      |      |      |
|---|------|------|------|
| 1 | 80R  | 105F | +1.3 |
| 2 | 50R  | 75F  | -0.3 |
| 3 | 0    | 0    | 0    |
| 4 | 50L  | 40B  | -1.0 |
| 5 | 120L | 15F  | -0.4 |
| 6 | 195L | 75F  | +0.2 |

This information will be used throughout the problem.

c. Computation of TGPC using the Registration/Special Correction Worksheet:

- (1) In the Transfer Limits block (fig 8-22):

(a) Circle the sector for which the corrections are to be computed (primary).

(b) Record the charge used for the corrections (4GB).

- ★ (c) Record deflection to the center (3200), left (3600), and right (2800) limits of the sector.

(d) Record the minimum (3500), maximum (7500), and center (5500) range for the sector.

| Rg K                                       |                    |               |                                     |                             |            |                           |              |  |  |  |  |
|--------------------------------------------|--------------------|---------------|-------------------------------------|-----------------------------|------------|---------------------------|--------------|--|--|--|--|
| TERRAIN GUN POSITION / SPECIAL CORRECTIONS |                    |               |                                     |                             |            |                           |              |  |  |  |  |
| VPA Sector TRANSFER LIMITS Chg 4GB         |                    |               |                                     |                             |            |                           |              |  |  |  |  |
| LEFT CENTER RIGHT                          |                    |               |                                     |                             |            |                           |              |  |  |  |  |
| CEN DF+400pt                               |                    | DF            | 3600                                | 3200                        | 2800       | DF                        | CEN DF-400pt |  |  |  |  |
| CEN RG-2000M                               |                    | RG            | 3500 (Min)                          | 5500                        | 7500 (Max) | RG                        | CEN RG+2000M |  |  |  |  |
| ⑥                                          | ⑦                  | ⑧             | ⑨                                   | ⑩                           | ⑪          | ⑫                         |              |  |  |  |  |
| MV Rg Corr                                 | Pos Rg Corr        | Total Rg Corr | Pos El Corr                         | Corr Rg                     | Fs         | Pos Ti Corr               | Gun          |  |  |  |  |
| ④ × ⑤                                      | (F = -)<br>(B = +) | ⑥ + ⑦ =       | ⑨ - DR<br>Per lpt<br>D El<br>(Tb F) | ⑩ ≈ 10M<br>Plus CEN<br>Rg * | ⑪          | ⑫ Minus<br>Fs - CEN<br>Rg |              |  |  |  |  |
| 1M                                         | 5M                 | 1M            | 1pt                                 | 10M                         | 0.1        | 0.1                       | #            |  |  |  |  |
|                                            |                    |               |                                     |                             |            |                           | 1            |  |  |  |  |
|                                            |                    |               |                                     |                             |            |                           | 2            |  |  |  |  |
|                                            |                    |               |                                     |                             |            |                           | 3            |  |  |  |  |
|                                            |                    |               |                                     |                             |            |                           | 4            |  |  |  |  |
|                                            |                    |               |                                     |                             |            |                           | 5            |  |  |  |  |
|                                            |                    |               |                                     |                             |            |                           | 6            |  |  |  |  |

Figure 8-22. Transfer limits block.

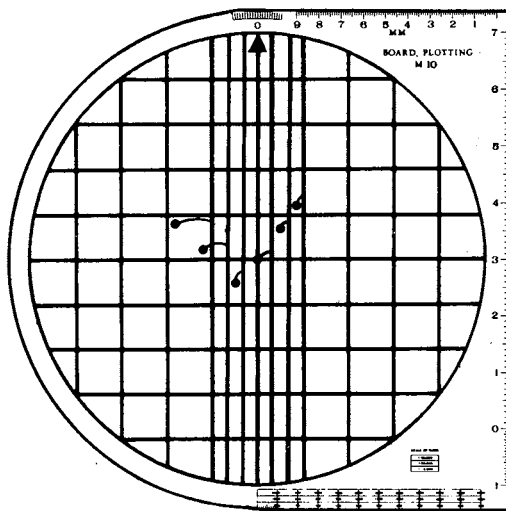
- (e) Record battery comparative VEs in column ④. Record plus VEs as increases (I) and minus VEs as decreases (D).

(2) To determine the corrections for TGPC for the center sector:

(a) Set the center of sector df off on the red scale over the index at the top of the plotting board.

- ★ (b) Determine the burst line to which each weapon corrects and the direction in which it must move (toward or away from battery center). Record this in the correction to burst line and direction of correction blocks on the TGPC section. Weapon 1 will not necessarily correct to burst line 1 and weapon 2 to burst line 2, etc. When determining the appropriate burst line for each weapon, start with the rightmost piece in relation to the line of fire (the red arrow) and correct it to the rightmost burst line. Subsequently, correct the second piece from the right (in relation to the line of fire) to the second burst line from the right. In addition, remember that each weapon is corrected to the nearest burst line that has not been used by another weapon.

## PIECE DISPLACEMENT



|    |      |      |
|----|------|------|
| #1 | 80R  | 105F |
| #2 | 50R  | 75F  |
| #3 | 0    | 0    |
| #4 | 50L  | 40B  |
| #5 | 120L | 15F  |
| #6 | 195L | 75F  |

| Gun | Corr To Burst Line | Dir Of Corr Toward -BC - Away -BC | Pos Lateral Corr (L/R) |
|-----|--------------------|-----------------------------------|------------------------|
| #   | #                  | T/A                               | 5M                     |
| 1   | 1                  | A                                 |                        |
| 2   | 2                  | A                                 |                        |
| 3   | 3                  | A                                 |                        |
| 4   | 4                  | T                                 |                        |
| 5   | 5                  | T                                 |                        |
| 6   | 6                  | T                                 |                        |

|     |                           |   |
|-----|---------------------------|---|
| WPN | #1 CORRECTS TO BURST LINE | 1 |
| #2  |                           | 2 |
| #3  |                           | 3 |
| #4  |                           | 4 |
| #5  |                           | 5 |
| #6  |                           | 6 |

Figure 8-23. Weapon to burst line corrections and recording blocks.

(c) Record the position lateral correction required to move each weapon to its selected burst line in column ① to the nearest 5 meters. Record the required position range corrections (the number of meters forward or behind battery center) in column ⑦, also to the nearest 5 meters (fig 8-24). If the weapon is forward of battery center, the correction is minus; if it is behind, the correction is plus.

(3) Using a GFT, determine 100/R values for the minimum and maximum ranges and record them in the heading of column ② (fig 8-25). The largest 100/R value used is 25; therefore, if 100/R is actually larger than 25, enter 25 on the Min Rg line. Enter the appropriate 100/R values in column ② (refer to Direction of Correction block). Now perform the computations shown in the heading of column ③. Label the

|      |                          |                                                |                                 |                                              |                         |                                      |                                                          | LPR Sector             |                                      | TRANSFER LIMITS                |                                                            |                                               |           | Chg 4GB                                            |     |   |
|------|--------------------------|------------------------------------------------|---------------------------------|----------------------------------------------|-------------------------|--------------------------------------|----------------------------------------------------------|------------------------|--------------------------------------|--------------------------------|------------------------------------------------------------|-----------------------------------------------|-----------|----------------------------------------------------|-----|---|
| Btry | ①                        | ②                                              | ③                               | ④                                            | ⑤                       | ⑥                                    | ⑦                                                        |                        |                                      |                                |                                                            |                                               |           |                                                    |     |   |
|      | Bn BP<br>Comp<br>VE      | MV Corr<br>Factor<br>D = _____<br>I = _____    | MV Rg<br>Corr<br>① × ② = ( )    | Achieved<br>Rg<br>③ × ④                      | Corr<br>Rg<br>③ × ④     | El ~ ⑤<br>Use EL<br>(Gageline)<br>pt | Ti ~ ⑤<br>Use Ti<br>(Gageline)<br>FS                     |                        |                                      |                                |                                                            |                                               |           |                                                    |     |   |
|      | M/S                      | M                                              | 10M                             | 10M                                          | 10M                     |                                      |                                                          |                        |                                      |                                |                                                            |                                               |           |                                                    |     |   |
|      |                          |                                                |                                 |                                              |                         |                                      |                                                          |                        |                                      |                                |                                                            |                                               |           |                                                    |     |   |
|      |                          |                                                |                                 |                                              |                         |                                      |                                                          | LEFT                   |                                      | CENTER                         |                                                            | RIGHT                                         |           |                                                    |     |   |
|      |                          |                                                |                                 |                                              |                         |                                      |                                                          | CEN DF + 400pt         | OF                                   | 3600<br>3500                   | 3200                                                       | 2800<br>7500                                  | DF        | CEN DF-400pt                                       |     |   |
|      |                          |                                                |                                 |                                              |                         |                                      |                                                          | CEN RG-2000M           | RG                                   | (Min)                          | 5500                                                       | (Max)                                         | RG        | CEN RG + 2000M                                     |     |   |
|      |                          |                                                |                                 |                                              |                         |                                      |                                                          |                        |                                      |                                |                                                            |                                               |           |                                                    |     |   |
| Gun  |                          |                                                | ①                               | ②                                            | ③                       | ④                                    | ⑤                                                        | ⑥                      | ⑦                                    | ⑧                              | ⑨                                                          | ⑩                                             | ⑪         | ⑫                                                  |     |   |
|      | Corr To<br>Burst<br>Line | Dir Of<br>Corr<br>Toward<br>-BC<br>Away<br>-BC | Pos<br>Lateral<br>Corr<br>(L/R) | 100/R<br>GFT *<br>T<br>Min Rg<br>A<br>Max Rg | Pos Di<br>Corr<br>(L/R) | Btry<br>Comp<br>VE<br>(I/O)          | MV Unit<br>Corr Fac<br>(Tbl F)<br>D + _____<br>I - _____ | MV Rg<br>Corr<br>④ × ⑤ | Pos Rg<br>Corr<br>(F = -)<br>(B = +) | Total<br>Rg<br>Corr<br>⑥ + ⑦ = | Pos El Corr<br>⑧ - DR<br>Per lpr<br>D El<br>(Tbl F)<br>( ) | Corr Rg<br>⑧ ≈ 10M<br>Plus CEN<br>Rg *<br>( ) | Fs ~<br>⑩ | Pos Ti<br>Corr<br>⑪ Minus<br>Fs ~ CEN<br>Rg<br>( ) | Gun |   |
|      | #                        | #                                              | T/A                             | 5M                                           | 1pt                     | 1pt                                  | 0.1M/S                                                   | 0.1 M                  | 1M                                   | 5M                             | 1M                                                         | 1pt                                           | 10M       | 0.1                                                | 0.1 | # |
|      | 1                        | 1                                              | A                               | R20                                          |                         |                                      | I1.3                                                     |                        |                                      | -105                           |                                                            |                                               |           |                                                    |     | 1 |
| 2    | 2                        | A                                              | R10                             |                                              |                         | D0.3                                 |                                                          |                        | -75                                  |                                |                                                            |                                               |           |                                                    | 2   |   |
| 3    | 3                        | A                                              | R20                             |                                              |                         |                                      |                                                          |                        | 0                                    |                                |                                                            |                                               |           |                                                    | 3   |   |
| 4    | 4                        | T                                              | R30                             |                                              |                         | D1.0                                 |                                                          |                        | +40                                  |                                |                                                            |                                               |           |                                                    | 4   |   |
| 5    | 5                        | T                                              | R60                             |                                              |                         | D0.4                                 |                                                          |                        | -15                                  |                                |                                                            |                                               |           |                                                    | 5   |   |
| 6    | 6                        | T                                              | R95                             |                                              |                         | I0.2                                 |                                                          |                        | -75                                  |                                |                                                            |                                               |           |                                                    | 6   |   |

Figure 8-24. Lateral and range corrections and comparative VEs.

| TRANSFER OF GFT SETTING |                          |                                                 |                              |                                                    |                         |                                      |                                      | TERRAIN GUN POSITION / SPECIAL CORRECTIONS |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|-------------------------|--------------------------|-------------------------------------------------|------------------------------|----------------------------------------------------|-------------------------|--------------------------------------|--------------------------------------|--------------------------------------------|------------------------------------|-----------------------------|---------------------------------------------------|----------------------------------------|---------------|----------------------------------------------------|--------------|--|---------|
| Btry                    | ①                        | ②                                               | ③                            | ④                                                  | ⑤                       | ⑥                                    | ⑦                                    | LPR Sector                                 | TRANSFER LIMITS                    |                             |                                                   |                                        |               |                                                    |              |  | Chg 460 |
|                         | Bn BP<br>Comp<br>VE      | MV Corr<br>Factor<br>D+<br>I-                   | MV Rg<br>Corr<br>①×②= ( )    | Achieved<br>Rg<br>10M                              | Corr<br>Rg<br>③+④= 10M  | El ~ ⑤<br>Use EL<br>(Gageline)<br>pt | Ti ~ ⑤<br>Use Ti<br>(Gageline)<br>FS |                                            | LEFT                               |                             |                                                   | CENTER                                 | RIGHT         |                                                    |              |  |         |
|                         | M/S                      | M                                               | 10M                          | 10M                                                | 10M                     |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            | CEN DF+400pt                       | DF                          | 3600                                              | 3200                                   | 2800          | DF                                                 | CEN DF-400pt |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            | CEN RG-2000M                       | RG                          | 3500<br>(Min)                                     | 5500                                   | 7500<br>(Max) | RG                                                 | CEN RG+2000M |  |         |
| Gun                     | Corr To<br>Burst<br>Line | Dir Of<br>Corr<br>Toward<br>-BC<br>Away<br>-BC- | ①                            | ②                                                  | ③                       | ④                                    | ⑤                                    | ⑥                                          | ⑦                                  | ⑧                           | ⑨                                                 | ⑩                                      | ⑪             | ⑫                                                  | Gun          |  |         |
|                         |                          |                                                 | Pos Lateral<br>Corr<br>(L/R) | 100/R<br>GFT *<br>T 25<br>Min Rg<br>A 14<br>Max Rg | Pos Df<br>Corr<br>(L/R) | Btry<br>Comp<br>VE<br>(I/D)          | MV Unit<br>Corr Fac<br>(Tbl F)       | MV Rg<br>Corr<br>④×⑤                       | Pos Rg<br>Corr<br>(F= -)<br>(B= +) | Total<br>Rg<br>Corr<br>⑥+⑦= | Pos El Corr<br>⑧-DR<br>Per lpt<br>D El<br>(Tbl F) | Corr Rg<br>⑧ ≈ 10M<br>Plus CEN<br>Rg * | Fs ~<br>⑩     | Pos Ti<br>Corr<br>⑪ Minus<br>Fs ~ CEN<br>Rg<br>( ) |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
|                         |                          |                                                 |                              |                                                    |                         |                                      |                                      |                                            |                                    |                             |                                                   |                                        |               |                                                    |              |  |         |
| #                       | #                        | T/A                                             | 5M                           | 1pt                                                | 1pt                     | 0.1M/S                               | 0.1 M                                | 1M                                         | 5M                                 | 1M                          | 1pt                                               | 10M                                    | 0.1           | 0.1                                                | #            |  |         |
| 1                       | 1                        | A                                               | R20                          | 14                                                 | R3                      | I1.3                                 |                                      |                                            | -105                               |                             |                                                   |                                        |               |                                                    | 1            |  |         |
| 2                       | 2                        | A                                               | R10                          | 14                                                 | R1                      | D0.3                                 |                                      |                                            | -75                                |                             |                                                   |                                        |               |                                                    | 2            |  |         |
| 3                       | 3                        | A                                               | R20                          | 14                                                 | R3                      | —                                    |                                      |                                            | 0                                  |                             |                                                   |                                        |               |                                                    | 3            |  |         |
| 4                       | 4                        | T                                               | R30                          | 25                                                 | R8                      | D1.0                                 |                                      |                                            | +40                                |                             |                                                   |                                        |               |                                                    | 4            |  |         |
| 5                       | 5                        | T                                               | R60                          | 25                                                 | R15                     | D0.4                                 |                                      |                                            | -15                                |                             |                                                   |                                        |               |                                                    | 5            |  |         |
| 6                       | 6                        | T                                               | R75                          | 25                                                 | R24                     | I0.2                                 |                                      |                                            | -75                                |                             |                                                   |                                        |               |                                                    | 6            |  |         |

Figure 8-25. 100/R and position deflection correction.

corrections L (for left) or R (for right). Express and record the value to the nearest mil. This correction will be sent to the guns and carried on the gunner's aid of the panoramic telescope. Different values of 100/R are used depending on whether the correction is toward or away from battery center. For pieces correcting away from battery center,

the greater the range fired, the farther away from the center of the sheaf the burst will land. If the 100/R value for the minimum range is used, at the maximum range the burst may fall too far away from the center of the sheaf. To insure a satisfactory sheaf at the maximum range, a smaller than necessary outward correction at the shorter

| TRANSFER OF GFT SETTING |                          |                                                 |                              |                                                                 |                           |                                      | TERRAIN GUN POSITION / SPECIAL CORRECTIONS                         |                      |                                    |                             |                                                                    |                                        |               |                                                    |                |  |
|-------------------------|--------------------------|-------------------------------------------------|------------------------------|-----------------------------------------------------------------|---------------------------|--------------------------------------|--------------------------------------------------------------------|----------------------|------------------------------------|-----------------------------|--------------------------------------------------------------------|----------------------------------------|---------------|----------------------------------------------------|----------------|--|
| Btry                    | ①                        | ②                                               | ③                            | ④                                                               | ⑤                         | ⑥                                    | ⑦                                                                  | L/P/R Sector         | TRANSFER LIMITS                    |                             |                                                                    |                                        |               |                                                    | Chg <u>4CB</u> |  |
|                         | Bn BP<br>Comp<br>VE      | MV Corr<br>Factor<br>D+<br>I-                   | MV Rg<br>Corr<br>①x②=<br>10M | Achieved<br>Rg<br>10M                                           | Corr<br>Rg<br>③+④=<br>10M | El ~ ⑤<br>Use EL<br>(Gageline)<br>pt | Ti ~ ⑤<br>Use Ti<br>(Gageline)<br>FS                               |                      | LEFT                               |                             |                                                                    | CENTER                                 | RIGHT         |                                                    |                |  |
|                         | M/S                      | M                                               |                              |                                                                 |                           |                                      |                                                                    |                      |                                    |                             |                                                                    |                                        |               |                                                    |                |  |
|                         |                          |                                                 |                              |                                                                 |                           |                                      |                                                                    |                      | CEN DF+400pt                       | DF                          | 3600                                                               | 3200                                   | 2800          | DF                                                 | CEN DF-400pt   |  |
|                         |                          |                                                 |                              |                                                                 |                           |                                      |                                                                    |                      | CEN RG-2000M                       | RG                          | 3500<br>(Min)                                                      | 5500                                   | 7500<br>(Max) | RG                                                 | CEN RG+2000M   |  |
| Gun                     | Corr To<br>Burst<br>Line | Dir Of<br>Corr<br>Toward<br>-BC<br>Away<br>-BC- | ①                            | ②                                                               | ③                         | ④                                    | ⑤                                                                  | ⑥                    | ⑦                                  | ⑧                           | ⑨                                                                  | ⑩                                      | ⑪             | ⑫                                                  | Gun            |  |
|                         |                          |                                                 | Pos Lateral<br>Corr<br>(L/R) | 100/R<br>GFT*<br>T <u>25</u><br>Min Rg<br>A <u>14</u><br>Max Rg | Pos Df<br>Corr<br>(L/R)   | Btry<br>Comp<br>VE<br>(I/D)          | MV Unit<br>Corr Fac<br>(Tbl F)<br>D+ <u>29.9</u><br>I- <u>23.2</u> | MV Rg<br>Corr<br>④x⑤ | Pos Rg<br>Corr<br>(F= -)<br>(B= +) | Total<br>Rg<br>Corr<br>⑥+⑦= | Pos El Corr<br>⑧-DR<br>Per lpt<br>D El<br>(Tbl F)<br>( <u>12</u> ) | Corr Rg<br>⑧ ≈ 10M<br>Plus CEN<br>Rg * | Fs ~<br>⑩     | Pos Ti<br>Corr<br>⑪ Minus<br>Fs ~ CEN<br>Rg<br>( ) |                |  |
| #                       | #                        | T/A                                             | 5M                           | 1pt                                                             | 1pt                       | 0.1M/S                               | 0.1 M                                                              | 1M                   | 5M                                 | 1M                          | 1pt                                                                | 10M                                    | 0.1           | 0.1                                                | #              |  |
| 1                       | 1                        | A                                               | R20                          | 14                                                              | R3                        | I1.3                                 | -23.2                                                              | -30                  | -105                               |                             |                                                                    |                                        |               |                                                    | 1              |  |
| 2                       | 2                        | A                                               | R10                          | 14                                                              | R1                        | D0.3                                 | +29.9                                                              | +9                   | -75                                |                             |                                                                    |                                        |               |                                                    | 2              |  |
| 3                       | 3                        | A                                               | R20                          | 14                                                              | R3                        |                                      |                                                                    |                      | 0                                  |                             |                                                                    |                                        |               |                                                    | 3              |  |
| 4                       | 4                        | T                                               | R30                          | 25                                                              | R8                        | D1.0                                 | +29.9                                                              | +30                  | +40                                |                             |                                                                    |                                        |               |                                                    | 4              |  |
| 5                       | 5                        | T                                               | R60                          | 25                                                              | R15                       | D0.4                                 | +29.9                                                              | +12                  | -15                                |                             |                                                                    |                                        |               |                                                    | 5              |  |
| 6                       | 6                        | T                                               | R95                          | 25                                                              | R24                       | I0.2                                 | -23.2                                                              | -5                   | -75                                |                             |                                                                    |                                        |               |                                                    | 6              |  |

Figure 8-26. Muzzle velocity range correction.

ranges is accepted. For pieces correcting toward BC, an insufficient correction may result at the minimum range; the maximum value is used and crossing of sheafs at larger ranges is accepted. A maximum 100/R value of 25 has been selected since tests have indicated that the corrections break down when larger 100/R values are used.

(4) Enter table F of the TFT with the range to the center of the sector expressed to the nearest 100 meters. Extract the muzzle velocity unit corrections for both an increase and decrease and record them in the heading of column (5). Also extract the DR per 1 mil D elevation factor and record it in the heading of column (9). Now enter the appropriate muzzle velocity unit correction factor in column (5). Multiply the values of columns (4) and (5) and enter the result to the nearest meter in column (6) (fig 8-26). If calibration data is not available, columns (4), (5), and (6) will not be used. Completion of the form will yield a solution for position corrections.

(5) Add the values of columns (6) and (7) and enter the answer in column (8) to the nearest meter. Divide the value in column (8) by the DR per 1 mil D elevation and enter the answer in column (9). This correction will be sent to the guns and carried on the correction counter of the range quadrant (fig 8-27).

(6) Express the total range correction in column (8) for each weapon to the nearest 10 meters and add it to the center range to determine the corrected range for each weapon and enter it in column (10). Determine the fuze setting (FS) corresponding to the corrected range for each weapon to the nearest 0.1 mil and enter it in column (11) by moving the MHL (using the appropriate GFT) over the corrected RG (from column (10)) and recording the FS to that RG read under the MHL. To determine the position time correction, subtract the fuze setting for the center range (col (12)) from the fuze setting for the corrected range (col (10)) and enter the difference in column (12). This

| TRANSFER OF GFT SETTING |                          |                                                  |                                           |                                                   |                              |                             |                                                      |                                         |                                                                                                                                                                                                                                         | TERRAIN GUN POSITION / SPECIAL CORRECTIONS |                                                               |                                          |              |                                                |     |  |  |  |  |
|-------------------------|--------------------------|--------------------------------------------------|-------------------------------------------|---------------------------------------------------|------------------------------|-----------------------------|------------------------------------------------------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---------------------------------------------------------------|------------------------------------------|--------------|------------------------------------------------|-----|--|--|--|--|
| Btry                    |                          | (1)<br>Bn BP<br>Comp<br>VE<br>M/S                | (2)<br>MV Corr<br>Factor<br>D+<br>I-<br>M | (3)<br>MV Rg<br>Corr<br>10M                       | (4)<br>Achieved<br>Rg<br>10M | (5)<br>Corr<br>Rg<br>10M    | (6)<br>El ~ (5)<br>(Use EL<br>Gageline)              | (7)<br>Ti ~ (5)<br>(Use Ti<br>Gageline) | (P/R) Sector <b>TRANSFER LIMITS</b> Chg <b>468</b><br>LEFT      CENTER      RIGHT<br>CEN DF +400m    DF    3600    3200    2800    DF    CEN DF -400m<br>CEN RG -2000M    RG    3500 (Min)    5500    7500 (Max)    RG    CEN RG +2000M |                                            |                                                               |                                          |              |                                                |     |  |  |  |  |
| Gun                     | Corr To<br>Burst<br>Line | Dir Of<br>Corr<br>Toward<br>-BC-<br>Away<br>-BC- | Pos<br>Lateral<br>Corr<br>(L/R)           | 100/R<br>GFT*<br>T 25<br>Min Rg<br>A 14<br>Max Rg | Pos Df<br>Corr<br>(L/R)      | Btry<br>Comp<br>VE<br>(I/D) | MV Unit<br>Corr Fac<br>(Tbl F)<br>D +29.9<br>I -23.2 | MV Rg<br>Corr<br>(4) x (5)              | Pos Rg<br>Corr<br>(F = -)<br>(B = +)                                                                                                                                                                                                    | Total<br>Rg<br>Corr<br>(6) + (7)           | Pos El Corr<br>(8) - DR<br>Per 1st<br>D El<br>(Tbl F)<br>(12) | Corr Rg<br>(8) ≈ 10M<br>Plus CEN<br>Rg * | Fs ~<br>(10) | Pos Ti<br>Corr<br>(11) Minus<br>Fs - CEN<br>Rg | Gun |  |  |  |  |
| #                       | #                        | T/A                                              | 5M                                        | 1m                                                | 1m                           | 0.1M/S                      | 0.1 M                                                | 1M                                      | 5M                                                                                                                                                                                                                                      | 1M                                         | 1m                                                            | 10M                                      | 0.1          | 0.1                                            | #   |  |  |  |  |
| 1                       |                          |                                                  | R20                                       | 14                                                | R3                           | I1.3                        | -23.2                                                | -30                                     | -105                                                                                                                                                                                                                                    | -135                                       | -11                                                           |                                          |              |                                                | 1   |  |  |  |  |
| 2                       |                          |                                                  | R10                                       | 14                                                | R1                           | D0.3                        | +29.9                                                | +9                                      | -75                                                                                                                                                                                                                                     | -66                                        | -6                                                            |                                          |              |                                                | 2   |  |  |  |  |
| 3                       |                          |                                                  | R20                                       | 14                                                | R3                           |                             |                                                      |                                         | 0                                                                                                                                                                                                                                       |                                            |                                                               |                                          |              |                                                | 3   |  |  |  |  |
| 4                       |                          |                                                  | R30                                       | 25                                                | R8                           | D1.0                        | +29.9                                                | +30                                     | +40                                                                                                                                                                                                                                     | +70                                        | +8                                                            |                                          |              |                                                | 4   |  |  |  |  |
| 5                       |                          |                                                  | R60                                       | 25                                                | R15                          | D0.4                        | +29.9                                                | +12                                     | -15                                                                                                                                                                                                                                     | -3                                         |                                                               |                                          |              |                                                | 5   |  |  |  |  |
| 6                       |                          |                                                  | R95                                       | 25                                                | R24                          | I0.2                        | -23.2                                                | -5                                      | -75                                                                                                                                                                                                                                     | -80                                        | -7                                                            |                                          |              |                                                | 6   |  |  |  |  |

Figure 8-27. Total range correction and position elevation correction.



| TRANSFER OF GFT SETTING |                             |                                                 |                                 |                                                                  |                         |                                | TERRAIN GUN POSITION / SPECIAL CORRECTIONS                         |                                                  |                                      |                             |                                                                    |                                                         |                   |                                                              |              |  |  |
|-------------------------|-----------------------------|-------------------------------------------------|---------------------------------|------------------------------------------------------------------|-------------------------|--------------------------------|--------------------------------------------------------------------|--------------------------------------------------|--------------------------------------|-----------------------------|--------------------------------------------------------------------|---------------------------------------------------------|-------------------|--------------------------------------------------------------|--------------|--|--|
| Btry                    | ①                           | ②                                               | ③                               | ④                                                                | ⑤                       | ⑥                              | ⑦                                                                  | LPR Sector <b>TRANSFER LIMITS</b> Chg <b>468</b> |                                      |                             |                                                                    |                                                         |                   |                                                              |              |  |  |
|                         | Bn BP<br>Comp<br>VE         | MV Corr<br>Factor<br>D+<br>I-                   | MV Rg<br>Corr<br>①×②=           | Achieved<br>Rg<br>( )                                            | Corr<br>Rg<br>③+④=      | El ~ ⑤<br>(Use EL<br>Gageline) | Ti ~ ⑤<br>(Use Ti<br>Gageline)                                     | LEFT                                             |                                      |                             | CENTER                                                             |                                                         | RIGHT             |                                                              |              |  |  |
|                         | M/S                         | M                                               | 10M                             | 10M                                                              | 10M                     | pt                             | FS                                                                 | CEN DF+400pt                                     | DF                                   | 3600                        | 3200                                                               | 2800                                                    | DF                | CEN DF-400pt                                                 |              |  |  |
|                         |                             |                                                 |                                 |                                                                  |                         |                                |                                                                    |                                                  | CEN RG-2000M                         | RG                          | 3500<br>(Min)                                                      | 5500                                                    | 7500<br>(Max)     | RG                                                           | CEN RG+2000M |  |  |
|                         |                             |                                                 |                                 |                                                                  |                         |                                |                                                                    |                                                  |                                      |                             |                                                                    |                                                         |                   |                                                              |              |  |  |
| Gun                     | Corr<br>To<br>Burst<br>Line | Dir Df<br>Corr<br>Toward<br>-BC<br>Away<br>-BC- | ①                               | ②                                                                | ③                       | ④                              | ⑤                                                                  | ⑥                                                | ⑦                                    | ⑧                           | ⑨                                                                  | ⑩                                                       | ⑪                 | ⑫                                                            | Gun          |  |  |
|                         |                             |                                                 | Pos<br>Lateral<br>Corr<br>(L/R) | 100/R<br>GFT *<br>T <b>25</b><br>Min Rg<br>A <b>14</b><br>Max Rg | Pos Df<br>Corr<br>(L/R) | Btry<br>Comp<br>VE<br>(I/D)    | MV Unit<br>Corr Fac<br>(Tbl F)<br>D+ <b>29.9</b><br>I- <b>23.2</b> | MV Rg<br>Corr<br>④×⑤                             | Pos Rg<br>Corr<br>(F = -)<br>(B = +) | Total<br>Rg<br>Corr<br>⑥+⑦= | Pos El Corr<br>⑨÷DR<br>Per 1pt<br>D El<br>(Tbl F)<br>( <b>12</b> ) | Corr Rg<br>⑩≈10M<br>Plus CEN<br>Rg *<br>( <b>5500</b> ) | Fs ~<br>⑪<br>(10) | Pos Ti<br>Corr<br>⑫ Minus<br>Fs~CEN<br>Rg<br>( <b>20.0</b> ) |              |  |  |
| #                       | #                           | T/A                                             | 5M                              | 1pt                                                              | 1pt                     | 0.1M/S                         | 0.1 M                                                              | 1M                                               | 5M                                   | 1M                          | 1pt                                                                | 10M                                                     | 0.1               | 0.1                                                          | #            |  |  |
| 1                       |                             |                                                 | R20                             | 14                                                               | R3                      | I1.3                           | -23.2                                                              | -30                                              | -105                                 | -135                        | -11                                                                | 5360                                                    | 19.4              | -0.6                                                         | 1            |  |  |
| 2                       |                             |                                                 | R10                             | 14                                                               | R1                      | D0.3                           | +29.9                                                              | +9                                               | -75                                  | -66                         | -6                                                                 | 5430                                                    | 19.7              | -0.3                                                         | 2            |  |  |
| 3                       |                             |                                                 | R20                             | 14                                                               | R3                      | —                              | —                                                                  | —                                                | 0                                    | —                           | —                                                                  | 5500                                                    | 20.0              | 0                                                            | 3            |  |  |
| 4                       |                             |                                                 | R30                             | 25                                                               | R8                      | D1.0                           | +29.9                                                              | +30                                              | +40                                  | +70                         | +6                                                                 | 5570                                                    | 20.3              | +0.3                                                         | 4            |  |  |
| 5                       |                             |                                                 | R60                             | 25                                                               | R15                     | D0.4                           | +29.9                                                              | +12                                              | -15                                  | -3                          | —                                                                  | 5500                                                    | 20.0              | 0                                                            | 5            |  |  |
| 6                       |                             |                                                 | R95                             | 25                                                               | R24                     | I0.2                           | -23.2                                                              | -5                                               | -75                                  | -80                         | -7                                                                 | 5420                                                    | 19.7              | -0.3                                                         | 6            |  |  |

Figure 8-28. Position time corrections.

correction will be sent to the guns and recorded by the chief of section who will apply it to the fuze setting sent down from the FDC for each HE/TI mission for which TGPC for the primary sector must be applied (fig 8-28).

(7) The appropriate deflection correction (col ③), elevation correction (col ⑨), and time correction (col ⑫) are sent to each gun for the primary sector (fig 8-29).

(8) For the left and right sectors, repeat the procedures in (1) thru (7) above. Use the center deflection to the center of each sector to determine displacement and use the appropriate sector range, charge, and MV unit corrections factors (they may differ from the primary sector).

| TRANSFER OF GFT SETTING |                          |                                                 |                              |                                                    |                         |                                | TERRAIN GUN POSITION / SPECIAL CORRECTIONS             |                        |                                      |                                |                                                             |                                                  |                   |                                                       |      |     |   |
|-------------------------|--------------------------|-------------------------------------------------|------------------------------|----------------------------------------------------|-------------------------|--------------------------------|--------------------------------------------------------|------------------------|--------------------------------------|--------------------------------|-------------------------------------------------------------|--------------------------------------------------|-------------------|-------------------------------------------------------|------|-----|---|
| Btry                    | ①                        | ②                                               | ③                            | ④                                                  | ⑤                       | ⑥                              | ⑦                                                      | LPR Sector             |                                      | TRANSFER LIMITS                |                                                             |                                                  |                   | Chg 468                                               |      |     |   |
|                         | Bn BP<br>Comp<br>VE      | MV Corr<br>Factor<br>D+<br>I-                   | MV Rg<br>Corr<br>①×②=        | Achieved<br>Rg<br>③+④=                             | Corr<br>Rg<br>③+④=      | El ~ ⑤<br>(Use EL<br>Gageline) | Ti ~ ⑤<br>(Use Ti<br>Gageline)                         |                        |                                      | LEFT                           |                                                             | CENTER                                           |                   | RIGHT                                                 |      |     |   |
|                         | M/S                      | M                                               | 10M                          | 10M                                                | 10M                     | m'                             | FS                                                     | CEN DF+400pt           | DF                                   | 3600                           | 3200                                                        | 2800                                             | DF                | CEN DF-400pt                                          |      |     |   |
|                         |                          |                                                 |                              |                                                    |                         |                                |                                                        | CEN RG-2000M           | RG                                   | 3500<br>(Min)                  | 5500                                                        | 7500<br>(Max)                                    | RG                | CEN RG+2000M                                          |      |     |   |
| Gun                     | Corr To<br>Burst<br>Line | Dir Df<br>Corr<br>Toward<br>-BC<br>Away<br>-BC- | Pos Lateral<br>Corr<br>(L/R) | ①                                                  | ②                       | ③                              | ④                                                      | ⑤                      | ⑥                                    | ⑦                              | ⑧                                                           | ⑨                                                | ⑩                 | ⑪                                                     | ⑫    | Gun |   |
|                         |                          |                                                 |                              | 100/R<br>GFT *<br>T 25<br>Min Rg<br>A 14<br>Max Rg | Pos Df<br>Corr<br>(L/R) | Btry<br>Comp<br>VE<br>(I/D)    | MV Unit<br>Corr Fac<br>(Tbl F)<br>D + 29.9<br>I - 23.2 | MV Rg<br>Corr<br>④ × ⑤ | Pos Rg<br>Corr<br>(F = -)<br>(B = +) | Total<br>Rg<br>Corr<br>⑥ + ⑦ = | Pos El Corr<br>⑨ ÷ DR<br>Per 1pt<br>D El<br>(Tbl F)<br>(12) | Corr Rg<br>⑩ ≈ 10M<br>Plus CEN<br>Rg *<br>(5500) | Fs ~<br>⑪<br>(10) | Pos Ti<br>Corr<br>⑫ Minus<br>Fs - CEN<br>Rg<br>(20.0) |      |     |   |
|                         | #                        | #                                               | T/A                          | 5M                                                 | 1pt                     | 1pt                            | 0.1M/S                                                 | 0.1 M                  | 1M                                   | 5M                             | 1M                                                          | 1pt                                              | 10M               | 0.1                                                   | 0.1  |     | # |
|                         | 1                        |                                                 |                              | R20                                                | 14                      | R3                             | I1.3                                                   | -23.2                  | -30                                  | -105                           | -135                                                        | -11                                              | 5360              | 19.4                                                  | -0.6 |     | 1 |
|                         | 2                        |                                                 |                              | R10                                                | 14                      | R1                             | D0.3                                                   | +29.9                  | +9                                   | -75                            | -66                                                         | -6                                               | 5430              | 19.7                                                  | -0.3 |     | 2 |
|                         | 3                        |                                                 |                              | R20                                                | 14                      | R3                             |                                                        |                        |                                      |                                |                                                             |                                                  | 5500              | 20.0                                                  | 0    |     | 3 |
|                         | 4                        |                                                 |                              | R30                                                | 25                      | R8                             | D1.0                                                   | +29.9                  | +30                                  | +40                            | +70                                                         | +6                                               | 5570              | 20.3                                                  | +0.3 |     | 4 |
| 5                       |                          |                                                 | R60                          | 25                                                 | R15                     | D0.4                           | +29.9                                                  | +12                    | -15                                  | -3                             |                                                             | 5500                                             | 20.0              | 0                                                     | 5    |     |   |
| 6                       |                          |                                                 | R95                          | 25                                                 | R24                     | I0.2                           | -23.2                                                  | -5                     | -75                                  | -80                            | -7                                                          | 5420                                             | 19.7              | -0.3                                                  | 6    |     |   |

Figure 8-29. Completed terrain gun position correction.

## 8-12. Hasty Terrain Gun Position Corrections

Even with well-trained FDC personnel, computing TGPC is time consuming. Corrections are required for firing shortly after occupation of position. If the advance party has determined displacement and computed TGPC, corrections will be available immediately. If the advance party has not been able to do this, hasty TGPC solutions must be determined and used until accurate TGPC are computed.

a. Hasty TGPC computations are designed to provide a converged sheaf at the center range of the TGPC sector.

For the hasty solution, piece displacement is estimated and fuze corrections are ignored.

b. Tables 8-3 through 8-10 show data for hasty TGPC. The data presented in these tables are:

(1) Midrange in 1000-meter increments.

(2) Charge—the charge most likely to be fired at the listed range.

(3) Deflection correction in mils to compensate for lateral piece displacement. These values have been determined to the nearest mil with the GST for each 20 meters of lateral displacement (20-200 meters).

$$\frac{\text{Lateral Displacement (D scale)}}{\text{Range in 1000s (C scale)}} =$$

Hasty TGPC df corr

(4) Position range correction in mils to compensate for piece displacement in range. QE corrections to the nearest mil for each 20 meters of front/rear displacement (20-100 meters) were computed using the range change per mil for the listed midranges.

$$\star \frac{\text{Displacement}}{\text{Range change per mil}} =$$

Hasty TGPC position rg corr

(5) MV correction in mils to compensate for the difference in shooting strengths (battery comparative VEs). MV corrections were determined using the formula:

$$\star \frac{\text{MVUCF} \times \text{btry comp VE}}{\text{Range change per mil}} =$$

Hasty TGPC MV corr

c. The steps to be followed in using these tables to determine hasty TGPC for a particular piece along a given azimuth of fire are listed below.

(1) Enter the table at the nearest range listed to the center of the TGPC sector.

(2) Extract the df correction by visually interpolating (if necessary) between the lateral displacements listed that bracket the estimated lateral displacement of the piece. If the piece is left of BC, the correction is to the right; if the piece is right of BC, the correction is to the left. This correction is placed on the gunner's aid of the panoramic telescope.

(3) Extract the position range correction in mils by visually interpolating between the range displacements listed that bracket the estimated displacement of the piece. If the piece is behind BC, the correction is plus; if the piece is forward of BC, the correction is minus.

(4) Extract the MV correction in mils for the battery comparative VE by visually interpolating between the VEs listed that bracket the VE of the piece. A positive VE will have a negative correction; a negative VE will have a positive correction.

(5) Add the position range correction in mils to the MV correction in mils. The answer is the elevation correction to be carried on the correction counter on the range quadrant.

*Example:*

(1) Given:

M109A1 unit

(a) Range to center of sector 9000 meters.



# C1, FM 6-40

(b) The executive officer estimates that 5 is 140 meters left of and 80 meters behind BC.

(c) Battery comparative VE of 5 is +2.3 m/s.

(2) Solution:

(a) Enter with midrange, 9000 meters. Hasty solution will be for charge 6.

(b) Extract df correction based on lateral displacement of 140 meters left. Since 5 is left of BC, the correction placed on the gunner's aid is R16.

(c) Extract the position range correction for the 80 meters displacement in range.

The correction is 5 mils and, since 5 is behind BC, it is +5 mils.

(d) Extract the MV correction for +2.3 m/s comparative VE. Visually interpolate between the listed values (if needed). The correction is -3 mils.

(e) Add the position range correction in mils to the MV correction in mils to determine the elevation correction for 5.  
 $+5 + (-3) = +2$  mils

FDC personnel can plot the estimated displacement in relation to the azimuth of lay on the plotting board and determine the estimated displacement for the left and right sectors rapidly.

Table 8-3. M101A1 105-mm Hasty TGPC

| Mid Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     | Position Correction |    |    |    |     | MV Correction (μ) |              |              |              |              |              |              |              |  |  |
|-----------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|---------------------|----|----|----|-----|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--|--|
|           |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                  | 40 | 60 | 80 | 100 | +1.5<br>-1.5      | +2.0<br>-2.0 | +2.5<br>-2.5 | +3.0<br>-3.0 | +3.5<br>-3.5 | +4.0<br>-4.0 | +4.5<br>-4.5 | +5.0<br>-5.0 |  |  |
| 2000      | 3      | 10                     | 20 | 31 | 41 | 51  | 61  | 71  | 81  | 92  | 102 | 2                   | 4  | 6  | 8  | 10  | -2<br>+2          | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -9<br>+9     |  |  |
| 3000      | 4      | 7                      | 14 | 20 | 27 | 34  | 41  | 47  | 54  | 61  | 68  | 2                   | 3  | 5  | 7  | 8   | -2<br>+3          | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -9<br>+9     |  |  |
| 4000      | 4      | 5                      | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 2                   | 4  | 6  | 8  | 10  | -3<br>+4          | -5<br>+5     | -6<br>+7     | -7<br>+8     | -8<br>+9     | -10<br>+11   | -11<br>+12   | -12<br>+8    |  |  |
| 5000      | 5      | 4                      | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                   | 3  | 5  | 6  | 8   | -2<br>+2          | -2<br>+3     | -3<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     |  |  |
| 6000      | 5      | 3                      | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 2                   | 4  | 6  | 7  | 9   | -2<br>+3          | -3<br>+5     | -4<br>+6     | -5<br>+7     | -6<br>+8     | -7<br>+9     | -8<br>+10    | -8<br>+11    |  |  |
| 7000      | 6      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 2                   | 3  | 5  | 7  | 8   | -2<br>+2          | -2<br>+3     | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     |  |  |
| 8000      | 7      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 1                   | 3  | 4  | 5  | 7   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4     | -5<br>+5     | -6<br>+5     | -5<br>+5     |  |  |
| 9000      | 7      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 2                   | 3  | 5  | 6  | 8   | -2<br>+2          | -3<br>+3     | -3<br>+3     | -4<br>+4     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -6<br>+6     |  |  |
| 10000     | 7      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 2                   | 4  | 6  | 8  | 10  | -3<br>+3          | -4<br>+4     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -9<br>+9     |  |  |

Table 8-4. M102 105-mm Hasty TGPC

| Mid Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     | Position Correction |    |    |    |     | MV Correction (#) |              |              |              |              |              |              |              |  |  |
|-----------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|---------------------|----|----|----|-----|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--|--|
|           |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                  | 40 | 60 | 80 | 100 | +1.5<br>-1.5      | +2.0<br>-2.0 | +2.5<br>-2.5 | +3.0<br>-3.0 | +3.5<br>-3.5 | +4.0<br>-4.0 | +4.5<br>-4.5 | +5.0<br>-5.0 |  |  |
| 2000      | 3      | 10                     | 20 | 31 | 41 | 51  | 61  | 71  | 81  | 92  | 102 | 2                   | 4  | 7  | 9  | 11  | -3<br>+3          | -3<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     | -9<br>+10    |  |  |
| 3000      | 4      | 7                      | 14 | 20 | 27 | 34  | 41  | 47  | 54  | 61  | 68  | 2                   | 4  | 6  | 8  | 10  | -3<br>+3          | -4<br>+4     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     | -9<br>+10    | -10<br>+11   |  |  |
| 4000      | 4      | 5                      | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 2                   | 5  | 8  | 10 | 12  | -5<br>+5          | -7<br>+7     | -8<br>+9     | -10<br>+11   | -12<br>+13   | -13<br>+14   | -15<br>+16   | -16<br>+18   |  |  |
| 5000      | 5      | 4                      | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                   | 4  | 6  | 7  | 9   | -4<br>+4          | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+10    | -10<br>+11   | -11<br>+12   | -12<br>+14   |  |  |
| 6000      | 5      | 3                      | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 3                   | 5  | 8  | 10 | 12  | -6<br>+7          | -8<br>+9     | -10<br>+11   | -12<br>+13   | -14<br>+15   | -16<br>+18   | -17<br>+20   | -19<br>+22   |  |  |
| 7000      | 6      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 1                   | 3  | 4  | 6  | 7   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+9     |  |  |
| 8000      | 7      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 2                   | 5  | 8  | 10 | 12  | -3<br>+3          | -4<br>+4     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     | -9<br>+10    | -10<br>+11   |  |  |
| 9000      | 7      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 2                   | 3  | 5  | 7  | 8   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+6     | -6<br>+6     | -7<br>+7     |  |  |
| 10000     | 7      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 2                   | 5  | 8  | 10 | 12  | -3<br>+3          | -4<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -9<br>+9     | -10<br>+10   | -11<br>+11   |  |  |

Table 8-5. M114A1 155-mm Hasty TGPC

| Mid Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     | Position Correction |    |    |    |     | MV Correction (u) |              |              |              |              |              |              |              |  |  |
|-----------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|---------------------|----|----|----|-----|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--|--|
|           |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                  | 40 | 60 | 80 | 100 | +1.5<br>-1.5      | +2.0<br>-2.0 | +2.5<br>-2.5 | +3.0<br>-3.0 | +3.5<br>-3.5 | +4.0<br>-4.0 | +4.5<br>-4.5 | +5.0<br>-5.0 |  |  |
| 3000      | 3      | 7                      | 14 | 20 | 27 | 34  | 41  | 47  | 54  | 61  | 68  | 2                   | 4  | 6  | 7  | 9   | -3<br>+3          | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     | -9<br>+10    |  |  |
| 4000      | 4      | 5                      | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 1                   | 3  | 4  | 6  | 7   | -2<br>+3          | -3<br>+4     | -3<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -7<br>+9     |  |  |
| 5000      | 4      | 4                      | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                   | 3  | 5  | 7  | 8   | -3<br>+4          | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     | -9<br>+10    | -10<br>+12   |  |  |
| 6000      | 5      | 3                      | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 1                   | 3  | 4  | 5  | 7   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+5     | -5<br>+5     |  |  |
| 7000      | 6      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -2<br>+2     | -2<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     |  |  |
| 8000      | 6      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 1                   | 2  | 4  | 5  | 6   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+4     | -5<br>+5     | -5<br>+5     | -6<br>+6     |  |  |
| 9000      | 6      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 1                   | 3  | 4  | 6  | 7   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -7<br>+8     |  |  |
| 10000     | 7      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+4     | -5<br>+5     | -5<br>+5     | -6<br>+6     |  |  |
| 11000     | 7      | 2                      | 4  | 6  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 1                   | 2  | 4  | 5  | 6   | -2<br>+2          | -3<br>+3     | -3<br>+4     | -4<br>+4     | -5<br>+5     | -5<br>+6     | -6<br>+6     | -7<br>+7     |  |  |
| 12000     | 7      | 2                      | 3  | 5  | 7  | 8   | 10  | 12  | 14  | 15  | 17  | 1                   | 3  | 4  | 6  | 7   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+8     |  |  |
| 13000     | 7      | 2                      | 3  | 5  | 6  | 8   | 9   | 11  | 13  | 14  | 16  | 2                   | 4  | 6  | 7  | 9   | -3<br>+3          | -4<br>+4     | -5<br>+6     | -6<br>+7     | -8<br>+8     | -9<br>+9     | -10<br>+10   | -11<br>+11   |  |  |
| 14000     | 7      | 1                      | 3  | 4  | 6  | 7   | 9   | 10  | 12  | 13  | 15  | 2                   | 5  | 8  | 10 | 12  | -5<br>+5          | -6<br>+6     | -8<br>+8     | -9<br>+10    | -11<br>+11   | -12<br>+13   | -14<br>+15   | -16<br>+16   |  |  |

Table 8-6. M109/M114A2 155-mm Hasty TGPC

| Mid Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     | Position Correction |    |    |    |     | MV Correction (μ) |              |              |              |              |              |              |              |  |  |
|-----------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|---------------------|----|----|----|-----|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--|--|
|           |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                  | 40 | 60 | 80 | 100 | +1.5<br>-1.5      | +2.0<br>-2.0 | +2.5<br>-2.5 | +3.0<br>-3.0 | +3.5<br>-3.5 | +4.0<br>-4.0 | +4.5<br>-4.5 | +5.0<br>-5.0 |  |  |
| 3000      | 3      | 7                      | 14 | 20 | 27 | 34  | 41  | 47  | 54  | 61  | 68  | 2                   | 3  | 5  | 7  | 8   | -2<br>+3          | -3<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+9     |              |  |  |
| 4000      | 4      | 5                      | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 1                   | 3  | 4  | 5  | 7   | -2<br>+2          | -2<br>+3     | -3<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     |              |  |  |
| 5000      | 4      | 4                      | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                   | 3  | 5  | 6  | 8   | -2<br>+3          | -3<br>+4     | -4<br>+5     | -5<br>+6     | -5<br>+8     | -7<br>+8     | -8<br>+10    |              |  |  |
| 6000      | 5      | 3                      | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 1                   | 3  | 4  | 5  | 7   | -2<br>+2          | -2<br>+2     | -2<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     |              |  |  |
| 7000      | 6      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -2<br>+2     | -2<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     |              |  |  |
| 8000      | 6      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 1                   | 2  | 4  | 5  | 6   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+4     | -5<br>+5     | -5<br>+6     |              |  |  |
| 9000      | 6      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 1                   | 3  | 4  | 6  | 7   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+6     | -7<br>+7     |              |  |  |
| 10000     | 7      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+5     | -5<br>+5     | -6<br>+6     |              |  |  |
| 11000     | 7      | 2                      | 4  | 6  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 1                   | 2  | 4  | 5  | 6   | -2<br>+2          | -3<br>+3     | -3<br>+3     | -4<br>+4     | -5<br>+5     | -5<br>+6     | -6<br>+7     |              |  |  |
| 12000     | 7      | 2                      | 3  | 5  | 7  | 8   | 10  | 12  | 14  | 15  | 17  | 1                   | 3  | 4  | 6  | 7   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -6<br>+7     | -7<br>+8     |              |  |  |
| 13000     | 7      | 2                      | 3  | 5  | 6  | 8   | 9   | 11  | 13  | 14  | 16  | 2                   | 4  | 6  | 7  | 9   | -3<br>+3          | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -10<br>+10   |              |  |  |
| 14000     | 7      | 1                      | 3  | 4  | 6  | 7   | 9   | 10  | 12  | 13  | 15  | 3                   | 6  | 9  | 11 | 14  | -5<br>+5          | -7<br>+7     | -9<br>+9     | -11<br>+11   | -12<br>+13   | -14<br>+14   | -16<br>+16   |              |  |  |

Table 8-7. M109A1 155-mm Hasty TGPC

| Mid<br>Range | Charge | Deflection Corrections (μ) |    |    |    |     |     |     |     |     |     | Position Correction (μ) |    |    |    |     |      | MV Correction (μ) |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|--------------|--------|----------------------------|----|----|----|-----|-----|-----|-----|-----|-----|-------------------------|----|----|----|-----|------|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|              |        | 20                         | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                      | 40 | 60 | 80 | 100 | +1.5 | +2.0              | +2.5 | +3.0 | +3.5 | +4.0 | +4.5 | +5.0 | -1.5 | -2.0 | -2.5 | -3.0 | -3.5 | -4.0 | -4.5 | -5.0 |
| 4,000        | 2      | 5                          | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 3                       | 7  | 10 | 13 | 17  | +7   | -10               | -12  | -15  | -17  | -19  | -22  | -24  | +8   | -11  | +14  | +16  | +19  | +22  | +24  | +27  |
| 5,000        | 4      | 4                          | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                       | 3  | 5  | 6  | 8   | +2   | +3                | +4   | +5   | +6   | +7   | +8   | +10  | -3   | -5   | -6   | -7   | -8   | -9   | -10  | -12  |
| 6,000        | 4      | 3                          | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 2                       | 4  | 5  | 7  | 9   | +4   | +6                | +7   | +9   | +10  | +12  | +13  | +6   | +2   | +3   | -3   | -4   | -5   | -6   | -7   | -8   |
| 7,000        | 5      | 3                          | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 2                       | 3  | 5  | 6  | 8   | -2   | -3                | -3   | -4   | -5   | -5   | -6   | -6   | +2   | +3   | +3   | +4   | +5   | +5   | +6   | +7   |
| 8,000        | 6      | 3                          | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 1                       | 2  | 4  | 5  | 6   | -2   | -2                | +3   | +3   | +4   | +5   | +5   | +6   | +2   | +2   | +3   | +3   | +4   | +5   | +5   | +6   |
| 9,000        | 6      | 2                          | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 1                       | 3  | 4  | 5  | 7   | -2   | -3                | +3   | -4   | +5   | +5   | +6   | -7   | +2   | +3   | -3   | +4   | +5   | +5   | +6   | +7   |
| 10,000       | 7      | 2                          | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 1                       | 2  | 3  | 4  | 5   | -2   | -2                | -3   | -3   | +4   | +4   | +5   | +6   | +2   | +2   | -3   | +3   | +4   | +5   | +5   | +6   |
| 11,000       | 7      | 2                          | 4  | 6  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 1                       | 2  | 4  | 5  | 6   | -2   | -3                | -3   | -4   | +5   | +5   | +6   | -7   | +2   | +3   | +3   | +4   | +5   | +5   | +6   | +6   |
| 12,000       | 8      | 2                          | 3  | 5  | 7  | 8   | 10  | 12  | 14  | 15  | 17  | 1                       | 2  | 3  | 4  | 5   | -1   | -2                | -2   | -3   | -3   | +4   | +4   | +5   | +1   | +2   | +2   | +3   | +3   | +4   | +4   | +5   |
| 13,000       | 8      | 2                          | 3  | 5  | 6  | 8   | 9   | 11  | 13  | 14  | 16  | 1                       | 2  | 3  | 4  | 5   | -2   | -2                | -3   | -3   | -4   | +4   | +4   | +5   | +2   | +2   | +3   | +3   | +4   | +4   | +5   | +6   |
| 14,000       | 8      | 1                          | 3  | 4  | 6  | 7   | 9   | 10  | 12  | 13  | 15  | 1                       | 2  | 3  | 4  | 6   | +2   | +3                | +3   | +4   | +5   | +5   | +6   | +6   | +2   | +3   | -3   | +4   | +5   | +5   | +6   | +6   |
| 15,000       | 8      | 1                          | 3  | 4  | 5  | 7   | 8   | 10  | 11  | 12  | 14  | 1                       | 2  | 4  | 5  | 6   | -2   | -3                | -4   | -4   | +5   | +6   | +7   | -7   | +2   | +3   | +4   | +5   | +6   | +6   | +7   | +8   |
| 16,000       | 8      | 1                          | 3  | 4  | 5  | 6   | 8   | 9   | 10  | 11  | 13  | 1                       | 3  | 4  | 6  | 7   | -3   | -4                | -4   | +5   | +6   | +7   | +8   | -9   | +3   | +4   | +4   | +5   | +6   | +7   | +8   | +9   |

Table 8-8. M110 8-inch Hasty TGPC

| Mid Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     | Position Correction |    |    |    |     | MV Correction (μ) |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|-----------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|---------------------|----|----|----|-----|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|           |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                  | 40 | 60 | 80 | 100 | +1.5              | +2.0 | +2.5 | +3.0 | +3.5 | +4.0 | +4.5 | +5.0 | -1.5 | -2.0 | -2.5 | -3.0 | -3.5 | -4.0 | -4.5 | -5.0 |
|           |        |                        |    |    |    |     |     |     |     |     |     |                     |    |    |    |     |                   | -2   | -3   | -4   | -4   | -5   | -6   | -6   | -7   | -2   | -3   | -4   | -4   | -5   | -6   | -6   |
| 4000      | 3      | 5                      | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 1                   | 3  | 4  | 6  | 7   | +3                | +4   | +4   | +5   | +5   | +6   | +7   | +8   | +9   | +9   | +9   | +9   | +9   | +9   | +9   | +9   |
| 5000      | 3      | 4                      | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                   | 3  | 7  | 6  | 8   | +4                | +5   | +6   | +7   | +8   | +9   | +11  | +12  | +12  | +12  | +12  | +12  | +12  | +12  | +12  | +12  |
| 6000      | 4      | 3                      | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 2                   | 3  | 4  | 5  | 7   | +2                | +2   | +3   | +3   | +4   | +4   | +5   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   |
| 7000      | 5      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 1                   | 2  | 4  | 5  | 6   | +2                | +2   | +3   | +3   | +4   | +4   | +5   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   |
| 8000      | 5      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 11                  | 2  | 4  | 5  | 6   | +2                | +2   | +3   | +4   | +4   | +5   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   |
| 9000      | 6      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 1                   | 2  | 3  | 4  | 6   | +2                | +2   | +3   | +4   | +4   | +5   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   |
| 10000     | 6      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 1                   | 2  | 4  | 5  | 6   | +2                | +3   | +3   | +4   | +5   | +5   | +6   | +7   | +7   | +7   | +7   | +7   | +7   | +7   | +7   | +7   |
| 11000     | 7      | 2                      | 4  | 6  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 1                   | 2  | 3  | 4  | 5   | +2                | +2   | +3   | +4   | +4   | +5   | +5   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   |
| 12000     | 7      | 2                      | 3  | 5  | 7  | 8   | 10  | 12  | 14  | 15  | 17  | 1                   | 2  | 3  | 4  | 5   | +2                | +3   | +3   | +4   | +4   | +5   | +5   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   | +6   |
| 13000     | 7      | 2                      | 3  | 5  | 6  | 8   | 9   | 11  | 13  | 14  | 16  | 1                   | 2  | 4  | 5  | 6   | +2                | +3   | +4   | +4   | +5   | +6   | +7   | +8   | +8   | +8   | +8   | +8   | +8   | +8   | +8   | +8   |
| 14000     | 7      | 1                      | 3  | 4  | 6  | 7   | 9   | 10  | 12  | 13  | 15  | 1                   | 3  | 4  | 5  | 7   | +3                | +4   | +4   | +5   | +6   | +7   | +8   | +9   | +9   | +9   | +9   | +9   | +9   | +9   | +9   | +9   |
| 15000     | 7      | 1                      | 3  | 4  | 5  | 7   | 8   | 10  | 11  | 12  | 14  | 2                   | 3  | 5  | 6  | 8   | +3                | +4   | +5   | +6   | +7   | +8   | +9   | +10  | +10  | +10  | +10  | +10  | +10  | +10  | +10  | +10  |
| 16000     | 7      | 1                      | 3  | 4  | 5  | 6   | 8   | 9   | 10  | 11  | 13  | 2                   | 4  | 7  | 9  | 11  | +5                | +6   | +8   | +9   | +11  | +12  | +14  | +15  | +16  | +16  | +16  | +16  | +16  | +16  | +16  | +16  |

Table 8-9. M110A1 8-inch Hasty TGPC

| Mid Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     | Position Correction |    |    |    |     | MV Correction (#) |              |              |              |              |              |              |              |  |  |
|-----------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|---------------------|----|----|----|-----|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--|--|
|           |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20                  | 40 | 60 | 80 | 100 | +1.5<br>-1.5      | +2.0<br>-2.0 | +2.5<br>-2.5 | +3.0<br>-3.0 | +3.5<br>-3.5 | +4.0<br>-4.0 | +4.5<br>-4.5 | +5.0<br>-5.0 |  |  |
| 4000      | 3      | 5                      | 10 | 15 | 20 | 25  | 31  | 36  | 41  | 46  | 51  | 1                   | 3  | 4  | 5  | 7   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -9<br>+9     |  |  |
| 5000      | 3      | 4                      | 8  | 12 | 16 | 20  | 24  | 29  | 33  | 37  | 41  | 2                   | 3  | 5  | 6  | 7   | -3<br>+4          | -4<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+10    | -9<br>+11    | -10<br>+12   |  |  |
| 6000      | 4      | 3                      | 7  | 10 | 14 | 17  | 20  | 24  | 27  | 31  | 34  | 1                   | 3  | 4  | 5  | 7   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4     | -5<br>+5     | -5<br>+5     | -5<br>+5     |  |  |
| 7000      | 5      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     | -5<br>+5     |  |  |
| 8000      | 5      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 1                   | 2  | 4  | 5  | 6   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+6     | -6<br>+6     |  |  |
| 9000      | 6      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 1                   | 2  | 3  | 4  | 5   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     | -5<br>+6     |  |  |
| 10000     | 6      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -2<br>+3     | -3<br>+3     | -3<br>+4     | -4<br>+5     | -5<br>+5     | -6<br>+6     | -6<br>+6     |  |  |
| 11000     | 7      | 2                      | 4  | 6  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 1                   | 2  | 3  | 4  | 4   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     | -5<br>+5     |  |  |
| 12000     | 7      | 2                      | 3  | 5  | 7  | 8   | 10  | 12  | 14  | 15  | 17  | 1                   | 2  | 3  | 4  | 5   | -1<br>+2          | -1<br>+2     | -2<br>+3     | -2<br>+4     | -2<br>+4     | -2<br>+5     | -3<br>+6     | -3<br>+0     |  |  |
| 13000     | 7      | 2                      | 3  | 5  | 6  | 8   | 9   | 11  | 13  | 14  | 16  | 1                   | 2  | 3  | 4  | 6   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+6     | -6<br>+7     | -7<br>+7     |  |  |
| 14000     | 8      | 1                      | 3  | 4  | 6  | 7   | 9   | 10  | 12  | 13  | 15  | 1                   | 2  | 3  | 4  | 4   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+5     | -5<br>+5     | -5<br>+6     |  |  |
| 15000     | 8      | 1                      | 3  | 4  | 5  | 7   | 8   | 10  | 11  | 12  | 14  | 1                   | 2  | 3  | 4  | 5   | -2<br>+2          | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+6     | -6<br>+6     |  |  |
| 16000     | 8      | 1                      | 3  | 4  | 5  | 6   | 8   | 9   | 10  | 11  | 13  | 1                   | 2  | 3  | 4  | 5   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -4<br>+5     | -5<br>+6     | -6<br>+6     | -6<br>+7     | -7<br>+7     |  |  |
| 17000     | 8      | 1                      | 2  | 4  | 5  | 6   | 7   | 8   | 10  | 11  | 12  | 1                   | 2  | 4  | 5  | 6   | -2<br>+2          | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6     | -6<br>+7     | -7<br>+7     | -8<br>+8     |  |  |
| 18000     | 8      | 1                      | 2  | 3  | 5  | 6   | 7   | 8   | 9   | 10  | 11  | 1                   | 3  | 4  | 5  | 7   | -3<br>+3          | -4<br>+4     | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     | -8<br>+9     | -10<br>+10   |  |  |
| 19000     | 8      | 1                      | 2  | 3  | 4  | 5   | 7   | 8   | 9   | 10  | 11  | 2                   | 3  | 5  | 6  | 8   | -3<br>+3          | -4<br>+4     | -6<br>+6     | -7<br>+7     | -8<br>+9     | -9<br>+9     | -10<br>+10   | -12<br>+11   |  |  |
| 20000     | 8      | 1                      | 2  | 3  | 4  | 5   | 6   | 7   | 8   | 9   | 10  | 2                   | 5  | 8  | 10 | 12  | -6<br>+6          | -7<br>+8     | -9<br>+9     | -11<br>+12   | -13<br>+14   | -15<br>+16   | -17<br>+18   | -18<br>+20   |  |  |

Table 8-10. M107 175-mm Hasty TGPC

| Mid<br>Range | Charge | Deflection Corrections |    |    |    |     |     |     |     |     |     |    |    | Position Correction |    |     |              |              |              | MV Correction (#) |              |              |              |              |  |  |  |  |  |
|--------------|--------|------------------------|----|----|----|-----|-----|-----|-----|-----|-----|----|----|---------------------|----|-----|--------------|--------------|--------------|-------------------|--------------|--------------|--------------|--------------|--|--|--|--|--|
|              |        | 20                     | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 20 | 40 | 60                  | 80 | 100 | +1.5<br>-1.5 | +2.0<br>-2.0 | +2.5<br>-2.5 | +3.0<br>-3.0      | +3.5<br>-3.5 | +4.0<br>-4.0 | +4.5<br>-4.5 | +5.0<br>-5.0 |  |  |  |  |  |
| 7000         | 1      | 3                      | 6  | 9  | 12 | 15  | 17  | 20  | 23  | 26  | 29  | 1  | 2  | 2                   | 3  | 4   | -1<br>+1     | -2<br>+2     | -2<br>+2     | -3<br>+3          | -3<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+4     |  |  |  |  |  |
| 8000         | 1      | 3                      | 5  | 8  | 10 | 13  | 15  | 18  | 20  | 23  | 25  | 1  | 2  | 3                   | 4  | 4   | -2<br>+2     | -2<br>+2     | -2<br>+3     | -3<br>+3          | -4<br>+4     | -4<br>+5     | -5<br>+5     | -5<br>+5     |  |  |  |  |  |
| 9000         | 1      | 2                      | 5  | 7  | 9  | 11  | 14  | 16  | 18  | 20  | 23  | 1  | 2  | 3                   | 4  | 5   | -2<br>+2     | -2<br>+2     | -3<br>+3     | -4<br>+4          | -4<br>+4     | -5<br>+5     | -5<br>+5     | -6<br>+6     |  |  |  |  |  |
| 10000        | 1      | 2                      | 4  | 6  | 8  | 10  | 12  | 14  | 16  | 18  | 20  | 1  | 2  | 3                   | 4  | 5   | -2<br>+2     | -3<br>+3     | -3<br>+4     | -4<br>+4          | -5<br>+5     | -6<br>+6     | -6<br>+7     | -7<br>+7     |  |  |  |  |  |
| 11000        | 1      | 2                      | 4  | 6  | 7  | 9   | 11  | 13  | 15  | 17  | 19  | 1  | 2  | 4                   | 5  | 6   | -2<br>+2     | -3<br>+3     | -4<br>+4     | -5<br>+5          | -6<br>+6     | -6<br>+7     | -7<br>+8     | -8<br>+8     |  |  |  |  |  |
| 12000        | 1      | 2                      | 3  | 5  | 7  | 8   | 10  | 12  | 14  | 15  | 17  | 1  | 2  | 4                   | 5  | 6   | -3<br>+3     | -4<br>+4     | -4<br>+4     | -5<br>+5          | -6<br>+6     | -7<br>+7     | -8<br>+8     | -10<br>+9    |  |  |  |  |  |
| 13000        | 2      | 2                      | 3  | 5  | 6  | 8   | 9   | 11  | 13  | 14  | 16  | 1  | 1  | 2                   | 3  | 3   | -1<br>+2     | -2<br>+2     | -2<br>+2     | -2<br>+3          | -3<br>+3     | -3<br>+4     | -4<br>+4     | -4<br>+4     |  |  |  |  |  |
| 14000        | 2      | 1                      | 3  | 4  | 6  | 7   | 9   | 10  | 12  | 13  | 15  | 1  | 1  | 2                   | 3  | 4   | -2<br>+2     | -2<br>+2     | -2<br>+2     | -3<br>+3          | -4<br>+4     | -4<br>+4     | -4<br>+4     | -5<br>+5     |  |  |  |  |  |
| 15000        | 2      | 1                      | 3  | 4  | 5  | 7   | 8   | 10  | 11  | 12  | 14  | 1  | 2  | 2                   | 3  | 4   | -2<br>+2     | -2<br>+2     | -3<br>+3     | -4<br>+4          | -4<br>+4     | -5<br>+5     | -5<br>+6     | -6<br>+6     |  |  |  |  |  |
| 16000        | 2      | 1                      | 3  | 4  | 5  | 6   | 8   | 9   | 10  | 11  | 13  | 1  | 2  | 3                   | 4  | 4   | -2<br>+2     | -3<br>+3     | -3<br>+3     | -4<br>+4          | -5<br>+5     | -5<br>+5     | -6<br>+6     | -7<br>+7     |  |  |  |  |  |
| 17000        | 2      | 1                      | 2  | 4  | 5  | 6   | 7   | 8   | 10  | 11  | 12  | 1  | 2  | 3                   | 4  | 5   | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+5          | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     |  |  |  |  |  |
| 18000        | 2      | 1                      | 2  | 3  | 5  | 6   | 7   | 8   | 9   | 10  | 11  | 1  | 2  | 3                   | 4  | 5   | -3<br>+3     | -3<br>+4     | -4<br>+4     | -5<br>+5          | -6<br>+6     | -7<br>+7     | -8<br>+8     | -9<br>+9     |  |  |  |  |  |
| 19000        | 2      | 1                      | 2  | 3  | 4  | 5   | 7   | 8   | 9   | 10  | 11  | 1  | 2  | 4                   | 5  | 6   | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6          | -7<br>+7     | -8<br>+8     | -9<br>+9     | -10<br>+10   |  |  |  |  |  |
| 20000        | 3      | 1                      | 2  | 3  | 4  | 5   | 6   | 7   | 8   | 9   | 10  | 0  | 1  | 2                   | 3  | 3   | -1<br>+1     | -2<br>+2     | -2<br>+2     | -2<br>+2          | -3<br>+3     | -3<br>+3     | -4<br>+4     | -4<br>+4     |  |  |  |  |  |
| 21000        | 3      | 1                      | 2  | 3  | 4  | 5   | 6   | 7   | 8   | 9   | 10  | 1  | 1  | 2                   | 2  | 3   | -1<br>+2     | -2<br>+2     | -2<br>+2     | -3<br>+3          | -3<br>+3     | -4<br>+4     | -4<br>+4     | -4<br>+4     |  |  |  |  |  |
| 22000        | 3      | 1                      | 2  | 3  | 4  | 5   | 6   | 6   | 7   | 8   | 9   | 1  | 1  | 2                   | 2  | 3   | -2<br>+2     | -2<br>+2     | -2<br>+2     | -3<br>+3          | -3<br>+4     | -4<br>+4     | -4<br>+4     | -5<br>+5     |  |  |  |  |  |
| 23000        | 3      | 1                      | 2  | 3  | 4  | 4   | 5   | 6   | 7   | 8   | 9   | 1  | 2  | 2                   | 2  | 3   | -2<br>+2     | -2<br>+2     | -3<br>+3     | -3<br>+3          | -4<br>+4     | -4<br>+4     | -5<br>+5     | -5<br>+5     |  |  |  |  |  |
| 24000        | 3      | 1                      | 2  | 3  | 3  | 4   | 5   | 6   | 7   | 8   | 8   | 1  | 2  | 2                   | 3  | 3   | -2<br>+2     | -2<br>+2     | -3<br>+3     | -4<br>+4          | -4<br>+4     | -5<br>+5     | -5<br>+5     | -6<br>+6     |  |  |  |  |  |
| 25000        | 3      | 1                      | 2  | 2  | 3  | 4   | 5   | 6   | 7   | 7   | 8   | 1  | 1  | 2                   | 3  | 4   | -2<br>+2     | -3<br>+3     | -3<br>+3     | -4<br>+4          | -5<br>+5     | -5<br>+6     | -6<br>+7     | -7<br>+7     |  |  |  |  |  |
| 26000        | 3      | 1                      | 2  | 2  | 3  | 4   | 5   | 5   | 6   | 7   | 8   | 1  | 2  | 2                   | 3  | 4   | -2<br>+2     | -3<br>+3     | -4<br>+4     | -4<br>+5          | -5<br>+5     | -6<br>+6     | -7<br>+7     | -8<br>+8     |  |  |  |  |  |
| 27000        | 3      | 1                      | 2  | 2  | 3  | 4   | 5   | 5   | 6   | 7   | 8   | 1  | 2  | 3                   | 3  | 4   | -2<br>+3     | -3<br>+3     | -4<br>+4     | -5<br>+5          | -6<br>+6     | -7<br>+7     | -7<br>+8     | -8<br>+9     |  |  |  |  |  |
| 28000        | 3      | 1                      | 1  | 2  | 3  | 4   | 4   | 5   | 6   | 7   | 7   | 1  | 2  | 3                   | 4  | 4   | -3<br>+3     | -4<br>+4     | -5<br>+5     | -6<br>+6          | -7<br>+7     | -8<br>+8     | -9<br>+9     | -10<br>+10   |  |  |  |  |  |
| 29000        | 3      | 1                      | 1  | 2  | 3  | 4   | 4   | 5   | 6   | 6   | 7   | 1  | 2  | 3                   | 4  | 5   | -3<br>+4     | -4<br>+5     | -6<br>+6     | -7<br>+7          | -8<br>+8     | -9<br>+9     | -10<br>+11   | -11<br>+12   |  |  |  |  |  |
| 30000        | 3      | 1                      | 1  | 2  | 3  | 3   | 4   | 5   | 5   | 6   | 7   | 1  | 2  | 3                   | 4  | 5   | -4<br>+4     | -5<br>+6     | -7<br>+7     | -8<br>+8          | -9<br>+10    | -10<br>+11   | -12<br>+13   | -13<br>+14   |  |  |  |  |  |
| 31000        | 3      | 1                      | 1  | 2  | 3  | 3   | 4   | 5   | 5   | 6   | 7   | 1  | 2  | 4                   | 5  | 6   | -5<br>+6     | -7<br>+7     | -8<br>+9     | -10<br>+11        | -12<br>+13   | -14<br>+14   | -15<br>+16   | -17<br>+18   |  |  |  |  |  |
| 32000        | 3      | 1                      | 1  | 2  | 3  | 3   | 4   | 4   | 5   | 6   | 6   | 2  | 4  | 6                   | 7  | 9   | -8<br>+9     | -11<br>+12   | -13<br>+15   | -16<br>+18        | -19<br>+21   | -21<br>+24   | -24<br>+27   | -27<br>+30   |  |  |  |  |  |

## Section IV. SPECIAL CORRECTIONS/ POSITION CORRECTIONS

### 8-13. Definition and Use

Special corrections are individual piece corrections applied to time, deflection, and quadrant elevation to place FFE bursts in precise location on a target. Special corrections are used for:

Individual piece locations (position correction)

Shooting strength of each piece (calculated correction)

Target shape and size

Knowing when to compute special corrections is as important as knowing how to compute them. Some factors that influence the use of special corrections are:

Time available for computation

Target size, shape, and proximity of friendly troops

Accuracy of target location

Availability of current corrections for nonstandard conditions

Whether or not the fires will be observed

Special corrections should be applied when and where they will increase the effectiveness of fires on the target. Due to the time required for computation, they are used only for FFE missions. If the above mentioned conditions do not favor the lengthy computations of special corrections, then the special techniques discussed in chapter 12 may be more practical.

### 8-14. Preparing the Plotting Board

The M10/17 plotting board is prepared for the manual solution of special corrections in the following manner:

a. Disassemble the plotting board by

removing the clear disk from the gridded base.

b. Draw sheaf lines on the base. Since the sheaf lines for TGPC and an open sheaf will both be on the base, they should be color coded to minimize confusion. Refer to table 8-1 for the distance between bursts for an open sheaf for the applicable caliber weapon.

c. Using the center red vertical line on the base as a focal point, draw a sheaf line one-half an effective burst width (25 meters for a 155-mm) to the right and a sheaf line one-half an effective burst width to the left. Draw the remaining four sheaf lines (for a six-gun battery) one effective burst width (50 meters for a 155-mm) apart, two on the right and two on the left.

d. To prepare the *disk* for M100 series sight deflection, extend the red df scale by crossing out the red numbers 1, 2, 3, 4, 5, after 32, and numbering from 33 to 63 (fig 8-30). (For the M12 series sights, extend the red df scale by numbering from 6 to 31 after the red numbers 1, 2, 3, 4, 5.)

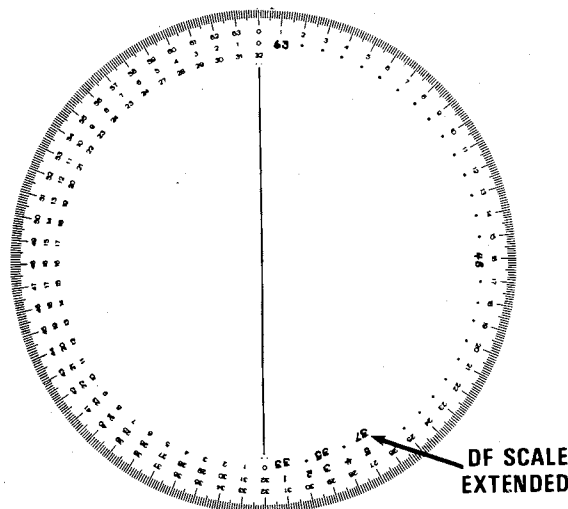


Figure 8-30. Extension of deflection scale for M100 series sight.

e. Reassemble the plotting board.

f. For describing targets on the plotting board, an azimuth index must be constructed. To construct an azimuth index:

- ★ (1) Orient the common deflection (*outer black scale*) over the red arrow (for M12 series sights, orient common deflection (*inner red scales*) over the red arrow).

(2) Opposite the azimuth of lay (*outer black scale*) mark an azimuth index on the base. The relationship between azimuth and deflection has now been established. To set off an azimuth, turn the azimuth on the outer black scale opposite the azimuth index.

g. The plotting board is now prepared for use in *special corrections*.

h. When working examples throughout this section, the following information for setting up the plotting board should be used.

- (1) Azimuth of lay - 5360 mils.

| (2) Piece | Displacement |      |
|-----------|--------------|------|
| 1         | 80R          | 105F |
| 2         | 50R          | 75F  |
| 3         | 0            | 0    |
| 4         | 50L          | 40B  |
| 5         | 120L         | 15F  |
| 6         | 195L         | 75F  |

#### 8-15. Plotting Special Sheafs on the Plotting Board

When calling for fire on an irregularly shaped target, the observer must describe the target in sufficient detail to allow the FDO to make a decision as to the best method of attack. When the FDC receives a call for fire that requires a special sheaf, it must be plotted on the plotting board so individual piece corrections can be computed. The target will be portrayed on the plotting board to scale and oriented according to the direction of fire.

a. *Plotting Targets Described by a Grid, Size, and Attitude.* Target attitude is the grid azimuth of the long axis of the target given from 0 to 6400 mils. The grid sent by the observer is the grid location of the center of the target. It will be represented by the center of the plotting board. The target must be drawn to scale on the plotting board disk and in the correct relationship to the direction of fire.

(1) Orient the disk with the attitude of the target on the outer black scale opposite the azimuth index.

(2) Using the same scale as the one on which the pieces are plotted (one small square = 10 meters), draw the target to scale, on the disk, over the red center line. (Draw a line, starting 100 meters above and below the center, over the red center line.) The FDO can now mark the points on the target for each weapon to engage.

(3) For placing burst points on a linear target, divide the length of the target by the number of firing units minus one (number of spaces between guns). For example, an M109 battery has six weapons minus one equals five. Five divided into a 200-meter-long target equals 40 meters. Plot the first burst point at one end of the target and then move toward the other end in 40-meter increments. The sixth burst point should plot at the other end of the target.

(4) Set off the deflection to the target (red scale) over the red index arrow. The target is now graphically portrayed with respect to the line of fire (red arrow).

- ★ (5) With an initial azimuth of lay of 5360 mils and a deflection of 3500 mils, the plotting board should look like that shown in figure 8-31.

E22 FIRE FOR EFFECT, GRID  
847751, INFANTRY IN TRENCH-  
LINE, SHEAF 50 BY 200, ATTIT-  
TUDE 2600, OVER.

(6) Special corrections are now computed as described in paragraph 8-16.

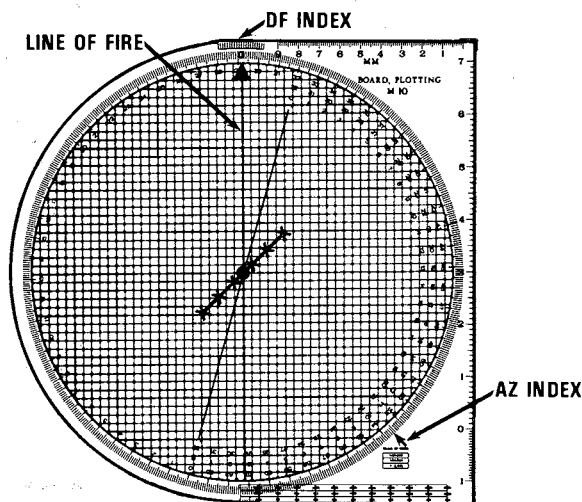


Figure 8-31. Target in relation to the azimuth of fire.

*b. Plotting Targets Described by Two Grids.* When the observer describes a target by two grids, the location of the center of the target must be computed to allow determination of CHT RG and CHT DF to only one point. This also allows the center of the target to be represented by the center of the plotting board. Using grids 168198 and 171196, the grid of the target center can be determined very rapidly by inspection using the following procedures (fig 8-32):

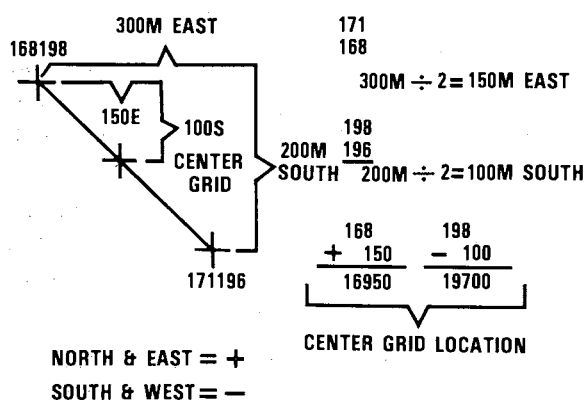


Figure 8-32. Plotting targets described by two grids.

(1) Orient the disk with the zero, on the outer black scale, opposite the azimuth index. This orients the clear disk north and the

center of the plotting board represents target center or grid 16951970.

(2) Plot the difference in easting and northing from the target center to the grids sent by the observer.

|               |       |       |
|---------------|-------|-------|
| Target center | 16950 | 19700 |
| Target grid   | 16800 | 19800 |
| Difference    | -150  | +100  |

North and east = +

West and south = -

Use this same procedure for the other target grid.

(3) Connect the two plotted points with a straight line through the center of the plotting board. The target grids sent by the observer are now portrayed on the plotting board (fig 8-33).

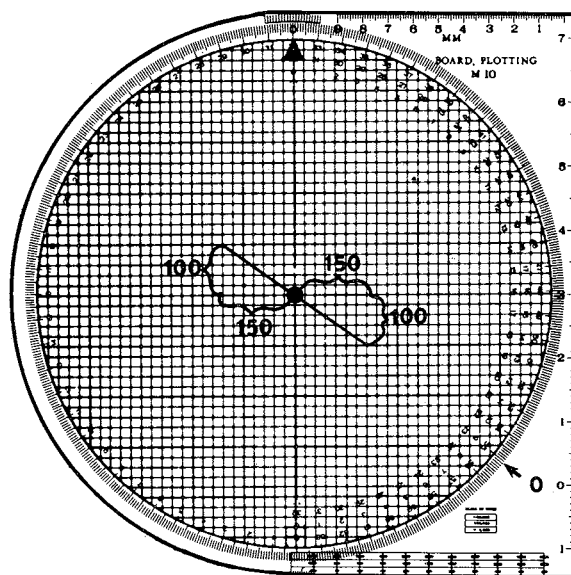


Figure 8-33. Two grid target.

(4) Rotate the disk until the target, constructed on the disk, is over the horizontal or vertical red center line, on the base. This will provide a scale to mark off the distance between bursts along the target.

(5) Set off the deflection to the target (red middle scale) over the red index arrow to graphically portray the target with respect to the line of fire.



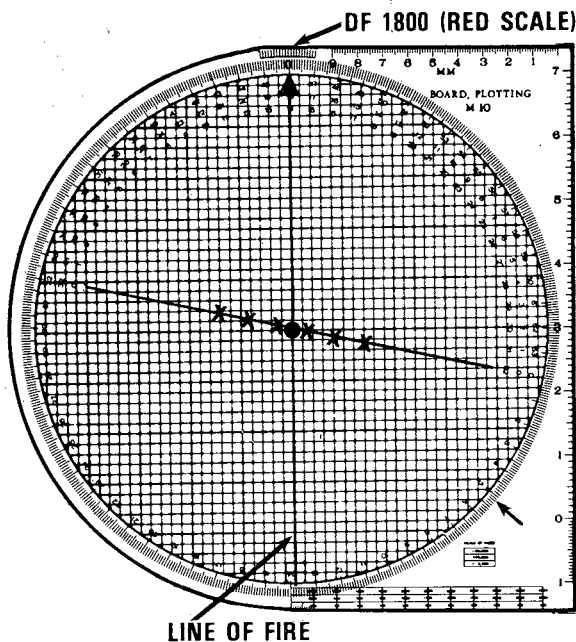


Figure 8-34. Target in relation to the azimuth of fire.

(6) Using a deflection of 1800 mils over the df index, the target should look like that shown in figure 8-34.

(7) Special corrections are now computed as described in paragraph 8-16.

*c. Plotting Targets Described by Three Grids.* When the observer describes a target with three grids, the middle grid will be represented by the center of the plotting board using the following procedures:

(1) Orient the disk with the zero on the outer black scale opposite the azimuth index.

(2) Determine the difference in easting and northing of the middle grid and the target end point grids.

|             |            |            |            |            |
|-------------|------------|------------|------------|------------|
| Middle grid | 169        | 198        | 169        | 198        |
| End point   | <u>168</u> | <u>197</u> | <u>170</u> | <u>197</u> |
|             | W100       | S100       | E100       | S100       |

(3) Plot the difference in easting and northing from the middle grid on the plotting board.

(4) Connect each plotted point to the center of the plotting board with a straight line.

(5) Rotate the disk until one of the constructed lines of the target on the disk is over the vertical or horizontal red center line on the base. This will provide a scale to mark off the distance between bursts. Select the points to be engaged on the constructed line. Do the same for the other constructed line. In this case the length of each leg of the target is 140 meters.

(6) Set off the deflection to the middle grid (red middle scale) over the red index arrow to graphically portray the target with respect to the line of fire and compute special corrections as described in paragraph 8-16.

(7) Using a deflection of 1600 mils over the df index, the target should look like that shown in figure 8-35.

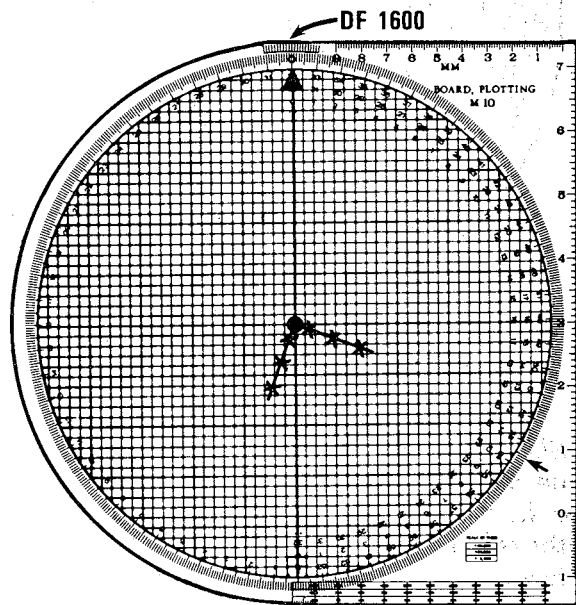


Figure 8-35. Target in relation to the azimuth of fire.

(8) These plotting techniques can be used on targets located in trenchlines, treelines, roads, etc. Locate these features on the map and then draw them to scale on the disk.

*d. Plotting Targets Requiring an Open Sheaf on Line.* The open sheaf on line was plotted on the base of the plotting board as described in paragraph 8-14, "Preparing the Plotting Board." An option to drawing open sheaf burst lines is to place Xs on the horizontal red center line at the points where

the burst lines would intersect (fig 8-36). These Xs represent the bursting points for an open sheaf on line. Set off the deflection to the target (red middle scale) over the red index arrow to graphically portray the target in relation to the weapon placement. Compute special corrections as described in paragraph 8-16.

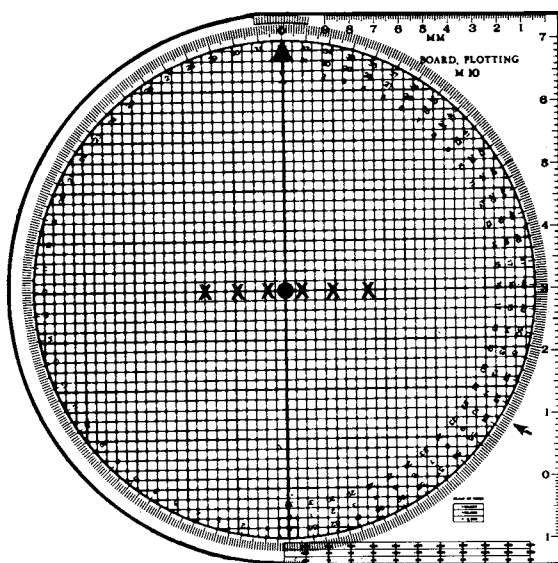


Figure 8-36. Open sheaf on line.

*e. Plotting Targets Requiring a Converged Sheaf.* The center of the plotting board is used to portray the target. Set off the deflection to the target (red middle scale) over the red index arrow to graphically portray the target in relation to the weapon placement. Compute special corrections as described in paragraph 8-16.

## 8-16. Determining Special Corrections/ Position Corrections

The form used for computation of special corrections is the Registration/Special Correction Worksheet (fig 8-37). For special corrections, the Corr to Burst Line column, the Dir of Corr column, and the Min and Max Rg portion of column ② are not used. In columns ⑩ and ⑫ the range to the target rather than the center range is used. The Transfer Limits block is not used except to

record the deflection and range to the target. The following situation will be used to work a "grid, size, and attitude" special correction problem.

**a. Given:**

(1) Dismounted infantry in a trenchline. Grid 6337 3862, size 50 meters x 200 meters, attitude 800.

(2) The fire order standards:

Unit to fire: Battery

Adjusting element: Number 3

Method of fire of adjusting element: One round

**Basis for correction:** Fastest method

**Distribution:** Primary

**Projectile: HE**

★ **Ammunition:** Lot RZ

Charge: 4

Fuze: Quick

**Number of rounds: One**

Range spread, lateral spread: Center range and deflection

**Time of opening fire:** When ready

(3) Fire order: FIRE FOR EFFECT, CANCEL TERRAIN CORRECTIONS, SPECIAL CORRECTIONS, SPECIAL SHEAF, FUZE TIME, TWO ROUNDS, AT MY COMMAND.

**Note.** AMC would usually be included to keep the element of surprise and thereby maximize effect on the target.

(4) **GFT settings:** GFT B: Chg 4, Lot RZ, Rg 5680, El 371, Ti 21.8. Tot Df Corr L4. GFT Df Corr R4.

(5) Same dis and comp VE from previous problem in TGPC.

| Piece | Displacement Relative<br>to Azimuth of Lay |      | Btry Comp<br>VE |
|-------|--------------------------------------------|------|-----------------|
| 1     | 80R                                        | 105F | +1.3            |
| 2     | 50R                                        | 75F  | -0.3            |
| 3     | 0                                          | 0    | 0               |
| 4     | 50L                                        | 40B  | -1.0            |
| ★ 5   | 120L                                       | 15F  | -0.4            |
| 6     | 195L                                       | 75F  | +0.2            |

(6) Azimuth of lay: 5360 mils.

(7) Chart range to target: 6030 meters, site  
+2.

## REGISTRATION/SPECIAL CORRECTION WORKSHEET

| REGISTRATION COMPUTATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------------------|------------------------|-------------------------------------|-----------------------------------|--------------------|--------------------------------------|---------------------|-----------------------------------|--------------------------|-----------------------------------------------|-------------------------------------|------------|----------------------------------------|--------------------|---------------------------------|------------------------|-------------------------------------|-----------------------------------|--------------------|--------------------------------------|---------------------|-----------------------------------|--------------------------|-----------------------------------------------|-------------------------------------|------------|----------------------------------------|-----|---|---|-----|----|-----|-----|--------|-------|----|----|----|-----|-----|-----|-----|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|
| ACHIEVED RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    |                                 |                        |                                     |                                   |                    | DEFLECTION CORRECTION                |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 1 Chart Rg                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                    | (10M)                           |                        |                                     |                                   |                    | 6 Corr Df (Reg)                      |                     | (1pt)                             |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 2 BP Displ (F/B +)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    | (10M)                           |                        |                                     |                                   |                    | 5 BP Displ Corr (L + /R -)           |                     | (1pt)                             |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 3 Achieved Rg (1 + 2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    | (10M)                           |                        |                                     |                                   |                    | 7 Adj Df (6 + 5)                     |                     | (1pt)                             |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| BP DISPLACEMENT CORRECTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 4 Lateral Displ (L/R)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                    | (5M)                            |                        |                                     |                                   |                    | 9 Total Df Corr (7 - 8) (+L/-R)      |                     | (1pt)                             |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 3 Achieved Rg                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    | (10M)                           |                        |                                     |                                   |                    | 10 Drift Corr (~ Adj El) (L)         |                     | (1pt)                             |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 5 BP Displ Corr (4 ÷ 3) L/R                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    | (1pt)                           |                        |                                     |                                   |                    | 11 GFT Df Corr (9 - 10)              |                     | (1pt)                             |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| GFT _____ : Chg _____ Lot _____ Rg _____ El _____ Ti _____<br>GFT _____ : Chg _____ Lot _____ Rg _____ El _____ Ti _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| DEFLECTION CORRECTION<br>Total _____ GFT _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| FADAC RESIDUALS Df ± _____ Fz ± _____ Rg K ± _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| TRANSFER OF GFT SETTING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| TERRAIN GUN POSITION / SPECIAL CORRECTIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| L/P/R Sector _____ TRANSFER LIMITS Chg _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| LEFT CENTER RIGHT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| CEN DF + 400pt DF _____ CEN DF - 400pt                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| CEN RG - 2000M RG (Min) _____ (Max) _____ CEN RG + 2000M                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| <table border="1"> <thead> <tr> <th>Gun</th> <th>Corr To Burst Line</th> <th>Dir Df Corr Toward -BC Away -BC</th> <th>Pos Lateral Corr (L/R)</th> <th>100/R GFT #<br/>T Min Rg<br/>A Max Rg</th> <th>Pos Df Corr (L/R)<br/>1 × 2<br/>100</th> <th>Btry Comp VE (I/D)</th> <th>MV Unit Corr Fac (Tbl F)<br/>D+<br/>I-</th> <th>MV Rg Corr<br/>4 × 5</th> <th>Pos Rg Corr<br/>(F = -)<br/>(B = +)</th> <th>Total Rg Corr<br/>6 + 7 =</th> <th>Pos El Corr<br/>8 ÷ DR<br/>Per Lpt D El (Tbl F)</th> <th>Corr Rg<br/>8 ≈ 10M<br/>Plus CEN Rg #</th> <th>Fs ~<br/>10</th> <th>Pos Ti Corr<br/>11 Minus<br/>Fs - CEN Rg</th> <th>Gun</th> </tr> </thead> <tbody> <tr> <td>#</td> <td>#</td> <td>T/A</td> <td>5M</td> <td>1pt</td> <td>1pt</td> <td>0.1M/S</td> <td>0.1 M</td> <td>1M</td> <td>5M</td> <td>1M</td> <td>1pt</td> <td>10M</td> <td>0.1</td> <td>0.1</td> <td>#</td> </tr> <tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td></tr> <tr><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2</td></tr> <tr><td>3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>3</td></tr> <tr><td>4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>4</td></tr> <tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>5</td></tr> <tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>6</td></tr> </tbody> </table> |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            | Gun                                    | Corr To Burst Line | Dir Df Corr Toward -BC Away -BC | Pos Lateral Corr (L/R) | 100/R GFT #<br>T Min Rg<br>A Max Rg | Pos Df Corr (L/R)<br>1 × 2<br>100 | Btry Comp VE (I/D) | MV Unit Corr Fac (Tbl F)<br>D+<br>I- | MV Rg Corr<br>4 × 5 | Pos Rg Corr<br>(F = -)<br>(B = +) | Total Rg Corr<br>6 + 7 = | Pos El Corr<br>8 ÷ DR<br>Per Lpt D El (Tbl F) | Corr Rg<br>8 ≈ 10M<br>Plus CEN Rg # | Fs ~<br>10 | Pos Ti Corr<br>11 Minus<br>Fs - CEN Rg | Gun | # | # | T/A | 5M | 1pt | 1pt | 0.1M/S | 0.1 M | 1M | 5M | 1M | 1pt | 10M | 0.1 | 0.1 | # | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 6 |
| Gun                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Corr To Burst Line | Dir Df Corr Toward -BC Away -BC | Pos Lateral Corr (L/R) | 100/R GFT #<br>T Min Rg<br>A Max Rg | Pos Df Corr (L/R)<br>1 × 2<br>100 | Btry Comp VE (I/D) | MV Unit Corr Fac (Tbl F)<br>D+<br>I- | MV Rg Corr<br>4 × 5 | Pos Rg Corr<br>(F = -)<br>(B = +) | Total Rg Corr<br>6 + 7 = | Pos El Corr<br>8 ÷ DR<br>Per Lpt D El (Tbl F) | Corr Rg<br>8 ≈ 10M<br>Plus CEN Rg # | Fs ~<br>10 | Pos Ti Corr<br>11 Minus<br>Fs - CEN Rg | Gun                |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| #                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | #                  | T/A                             | 5M                     | 1pt                                 | 1pt                               | 0.1M/S             | 0.1 M                                | 1M                  | 5M                                | 1M                       | 1pt                                           | 10M                                 | 0.1        | 0.1                                    | #                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        | 1                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        | 2                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        | 3                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        | 4                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        | 5                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                    |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        | 6                  |                                 |                        |                                     |                                   |                    |                                      |                     |                                   |                          |                                               |                                     |            |                                        |     |   |   |     |    |     |     |        |       |    |    |    |     |     |     |     |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |

DA FORM 4757

1 Oct 78

FOR USE OF THIS FORM, SEE FM 6-40:  
THE PROPONENT AGENCY IS TRADOC.

\* FOR SPECIAL CORR USE CHART RANGE TO TARGET

Figure 8-37. Registration/TGPC worksheet.

(8) The heading of the Record of Fire in figure 8-38.

c. Solution:

b. Required:

Complete forms for special corrections.

(1) Record the df corr, chart df, chart range, and site in the appropriate blocks of the Record of Fire.

## RECORD OF FIRE

|                                                                    |  |                  |  |                               |  |                     |  |                                           |  |                    |  |
|--------------------------------------------------------------------|--|------------------|--|-------------------------------|--|---------------------|--|-------------------------------------------|--|--------------------|--|
| Observer <b>P24</b>                                                |  | CALL FOR FIRE    |  | Tgt _____                     |  | TGT ALT <b>387</b>  |  | GFT R4                                    |  | △ FS               |  |
| Grid: <b>6337 3862</b>                                             |  | AF/EF IS/S _____ |  | Tgt _____                     |  | BTRY ALT <b>377</b> |  | DFT L9                                    |  | 100/R <b>17</b>    |  |
| Polar: Dir _____ Dis _____ U/D _____ VA _____                      |  | Shift _____      |  | Dir _____ L/R _____ U/D _____ |  | VI + 10             |  |                                           |  | /R _____           |  |
| In F IN TRENCH LINE, SHEAF SOX 200, ATT 800, VT                    |  | Si ÷ 10          |  | 10m Si                        |  |                     |  |                                           |  | 20/R <b>3</b>      |  |
| FIRE ORDER <b>FFE, CANCEL TERR CORR, SPEC CORR, FZ TI (2), AMC</b> |  |                  |  |                               |  | Df Corr <b>15</b>   |  |                                           |  | NOB Corr <b>+3</b> |  |
| INITIAL FIRE COMMANDS <b>FM MF BTRY (2)</b>                        |  |                  |  |                               |  | Rg <b>6030</b>      |  | Chf Df <b>3430</b>                        |  | SI <b>+2</b>       |  |
| Sp Instr <b>AMC, CANCEL TGPC, SPEC CORR</b>                        |  |                  |  |                               |  | Sh _____ Lot _____  |  | Chg <b>4</b> Fz <b>TI</b> Ti <b>(236)</b> |  | EI <b>404</b>      |  |
| MTO <b>G38, TI, (2)</b>                                            |  |                  |  |                               |  | T <b>(300)</b>      |  | PER _____ TF _____                        |  | QE <b>(409)</b>    |  |
|                                                                    |  |                  |  |                               |  |                     |  | in Eff                                    |  | Ammo Exp           |  |

Figure 8-38. Record of fire.

|     |                    |                                                 | ①                               | ②                                            | ③                                       | ④                           | ⑤                                                        | ⑥                      | ⑦                                    | ⑧                              |
|-----|--------------------|-------------------------------------------------|---------------------------------|----------------------------------------------|-----------------------------------------|-----------------------------|----------------------------------------------------------|------------------------|--------------------------------------|--------------------------------|
| Gun | Corr To Burst Line | Dir Of Corr<br>Toward<br>-BC -<br>Away<br>-BC - | Pos<br>Lateral<br>Corr<br>(L/R) | 100/R<br>GFT *<br>T<br>Min Rg<br>A<br>Max Rg | Pos Df<br>Corr<br>(L/R)<br>① × ②<br>100 | Btry<br>Comp<br>VE<br>(I/D) | MV Unit<br>Corr Fac<br>(Tbl F)<br>D + _____<br>I - _____ | MV Rg<br>Corr<br>④ × ⑤ | Pos Rg<br>Corr<br>(F = -)<br>(B = +) | Total<br>Rg<br>Corr<br>⑥ + ⑦ = |
| #   | #                  | T/A                                             | 5M                              | 1gr                                          | 1gr                                     | 0.1M/S                      | 0.1 M                                                    | 1M                     | 5M                                   | 1M                             |
| 1   |                    |                                                 | L10                             |                                              |                                         |                             |                                                          |                        | -130                                 |                                |
| 2   |                    |                                                 | L10                             |                                              |                                         |                             |                                                          |                        | -90                                  |                                |
| 3   |                    |                                                 | R20                             |                                              |                                         |                             |                                                          |                        | -10                                  |                                |
| 4   |                    |                                                 | R40                             |                                              |                                         |                             |                                                          |                        | +40                                  |                                |
| 5   |                    |                                                 | R60                             |                                              |                                         |                             |                                                          |                        | -15                                  |                                |
| 6   |                    |                                                 | R85                             |                                              |                                         |                             |                                                          |                        | -70                                  |                                |

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPONENT AGENCY IS TRADOC.

(2) Plot the weapons on the plotting board using piece distribution relative to the azimuth of lay and plot the target on the plotting board IAW the instructions in paragraph 8-14. Mark the burst points for each round.

answers in column ③ (fig 8-41) and in the DF Corr column of the Subsequent Fire Commands block on the Record of Fire (fig 8-40).

★ (5) Record the battery comparative VEs in column ④ (fig 8-41). Enter table B of the TFT, with chart range and VI expressed to nearest 100 meters, and determine complementary range. Add complementary range to the chart range to determine entry range. Enter table F of the TFT with entry range to the nearest 100 meters and extract the muzzle velocity unit correction factor for both an increase and a decrease and the DR per 1 mil D elevation factor. Record these values in the headings of column ⑤ and column ⑨, respectively. Based on the battery comparative VE of each weapon,

|                       |          |          |             |                          |            |     |             |                 |             |             |             |           |          |    |     |      |
|-----------------------|----------|----------|-------------|--------------------------|------------|-----|-------------|-----------------|-------------|-------------|-------------|-----------|----------|----|-----|------|
| INITIAL FIRE COMMANDS |          |          | FM          | MF                       | Rg         |     |             | Cht Df          |             |             | EI          |           |          |    |     |      |
| Sp Instr              |          |          |             | Sh                       |            | Lot |             | Chg             | Fz          | Ti          | Df          |           | QE       |    |     |      |
| MTO                   |          |          |             | T                        |            | PER |             | TF              |             | in Eff      |             |           | Ammo Exp |    |     |      |
| Tgt                   | Location | Priority | Firing Unit | SUBSEQUENT FIRE COMMANDS |            |     |             |                 |             |             |             |           |          |    |     |      |
| Dir, MF<br>Sh, Fz     | Dev      | Rg       | HOB<br>Corr | MF, Sh,<br>Chg, Fz       | FS<br>Corr | Ti  | Chart<br>Df | Df Corr<br>(LS) | Df<br>Fired | Chart<br>Rg | HOB<br>Corr | Si<br>( ) | EI       | QE | Exp | Type |
|                       |          |          |             | # 1                      |            |     |             | L2              |             |             |             |           |          |    |     |      |
|                       |          |          |             | # 2                      |            |     |             | L2              |             |             |             |           |          |    |     |      |
|                       |          |          |             | # 3                      |            |     |             | R3              |             |             |             |           |          |    |     |      |
|                       |          |          |             | # 4                      |            |     |             | R7              |             |             |             |           |          |    |     |      |
|                       |          |          |             | # 5                      |            |     |             | R10             |             |             |             |           |          |    |     |      |
|                       |          |          |             | # 6                      |            |     |             | R14             |             |             |             |           |          |    |     |      |

**8-29**

| TRANSFER OF GFT SETTING                                                                                                                                                                               |                    |                                              |                                   |                                                   |                                                |                                  |                                                             | TERRAIN GUN POSITION / SPECIAL CORRECTIONS                                                                                                                |                                           |                                     |                                                          |                                             |                |                                                         |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------------|-----------------------------------|---------------------------------------------------|------------------------------------------------|----------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------------------------------------|----------------------------------------------------------|---------------------------------------------|----------------|---------------------------------------------------------|-----|
| ① ② ③ ④ ⑤ ⑥ ⑦<br>Bn BP MV MV Achieved Corr El ~ ⑤ Ti ~ ⑤<br>Comp Factor Rg Rg ~<br>VE D+ _____<br>  - _____<br>M/S M 10M 10M 10M pt FS<br>(① × ② = ( ③ + ④ = Use EL / Use Ti<br>(Gageline) (Gageline) |                    |                                              |                                   |                                                   |                                                |                                  |                                                             | L/P/R Sector TRANSFER LIMITS Chg _____<br>LEFT CENTER RIGHT<br>CEN DF+400pt DF (Min) (Max) RG CEN DF-400pt<br>CEN RG-2000M RG (Min) (Max) RG CEN RG+2000M |                                           |                                     |                                                          |                                             |                |                                                         |     |
| Gun                                                                                                                                                                                                   | Corr To Burst Line | Dir Of Corr<br>Toward<br>-BC<br>Away<br>-BC- | ①<br>Pos Lateral<br>Corr<br>(L/R) | ②<br>100/R<br>GFT *<br>T<br>Min Rg<br>A<br>Max Rg | ③<br>Pos Df<br>Corr<br>(L/R)<br>① × ②<br>100 = | ④<br>Btry<br>Comp<br>VE<br>(I/D) | ⑤<br>MV Unit<br>Corr Fac<br>(Tbl F)<br>D + 32.4<br>I = 25.3 | ⑥<br>MV Rg<br>Corr<br>④ × ⑤                                                                                                                               | ⑦<br>Pos Rg<br>Corr<br>(F = -)<br>(B = +) | ⑧<br>Total<br>Rg<br>Corr<br>⑥ + ⑦ = | ⑨<br>Pos El Corr<br>Per 1pt<br>D El<br>(Tbl F)<br>( // ) | ⑩<br>Corr Rg<br>⑧ ≈ 10M<br>Plus CEN<br>Rg * | ⑪<br>Fs ~<br>⑩ | ⑫<br>Pos Ti<br>Corr<br>⑪ Minus<br>Fs ~ CEN<br>Rg<br>( ) | Gun |
| #                                                                                                                                                                                                     | #                  | T/A                                          | 5M                                | 1pt                                               | 1pt                                            | 0.1M/S                           | 0.1 M                                                       | 1M                                                                                                                                                        | 5M                                        | 1M                                  | 1pt                                                      | 10M                                         | 0.1            | 0.1                                                     | #   |
| 1                                                                                                                                                                                                     |                    |                                              | L10                               | 17                                                | L2                                             | I 1.3                            | -25.3                                                       | -33                                                                                                                                                       | -130                                      |                                     |                                                          |                                             |                |                                                         | 1   |
| 2                                                                                                                                                                                                     |                    |                                              | L10                               | 17                                                | L2                                             | D0.3                             | +32.4                                                       | +10                                                                                                                                                       | -90                                       |                                     |                                                          |                                             |                |                                                         | 2   |
| 3                                                                                                                                                                                                     |                    |                                              | R20                               | 17                                                | R3                                             | 0                                |                                                             | 0                                                                                                                                                         | -10                                       |                                     |                                                          |                                             |                |                                                         | 3   |
| 4                                                                                                                                                                                                     |                    |                                              | R40                               | 17                                                | R7                                             | D1.0                             | +32.4                                                       | +32                                                                                                                                                       | +40                                       |                                     |                                                          |                                             |                |                                                         | 4   |
| 5                                                                                                                                                                                                     |                    |                                              | R60                               | 17                                                | R10                                            | D0.4                             | +32.4                                                       | +13                                                                                                                                                       | -15                                       |                                     |                                                          |                                             |                |                                                         | 5   |
| 6                                                                                                                                                                                                     |                    |                                              | R85                               | 17                                                | R14                                            | I0.2                             | -25.3                                                       | -5                                                                                                                                                        | -70                                       |                                     |                                                          |                                             |                |                                                         | 6   |

Figure 8-41. Range correction.

select and record the appropriate MVUCF for each piece. Perform the computations in the heading of column ⑥ and record the answers (fig 8-41). If calibration data is not available, columns ④, ⑤, and ⑥ will not be used. Completion of the form will yield a solution for position corrections.

(6) Perform the computations in the heading of column ⑧ and record the answers in column ⑧. Perform the computations in the heading of column ⑨ and record the answers in column ⑨ (fig 8-42) and in the EL column of the Subsequent Fire Commands block of the Record of Fire (fig 8-45).

| TRANSFER OF GFT SETTING |                       |                                                  |                                     |                                                     |                                |                                      |                                       | TERRAIN GUN POSITION / SPECIAL CORRECTIONS |                       |                            |                                                              |                                                  |                      |                                                        |     |
|-------------------------|-----------------------|--------------------------------------------------|-------------------------------------|-----------------------------------------------------|--------------------------------|--------------------------------------|---------------------------------------|--------------------------------------------|-----------------------|----------------------------|--------------------------------------------------------------|--------------------------------------------------|----------------------|--------------------------------------------------------|-----|
|                         | (1)                   | (2)                                              | (3)                                 | (4)                                                 | (5)                            | (6)                                  | (7)                                   | L/P/R Sector                               | TRANSFER LIMITS       |                            |                                                              | Chg _____                                        |                      |                                                        |     |
| Btry                    | Bn BP<br>Comp<br>VE   | MV Corr<br>Factor<br>D-<br>I=                    | MV Rg<br>Corr                       | Achieved<br>Rg                                      | Corr<br>Rg                     | El ~ (5)<br><br>Use EL<br>(Gageline) | Ti ~ (5)<br><br>Use Ti<br>(Gageline)  |                                            |                       |                            |                                                              |                                                  |                      |                                                        |     |
|                         | M/S                   | M                                                | 10M                                 | 10M                                                 | 10M                            | m                                    | FS                                    |                                            |                       |                            |                                                              |                                                  |                      |                                                        |     |
|                         |                       |                                                  |                                     |                                                     |                                |                                      |                                       | CEN DF + 400pt                             | DF                    |                            |                                                              |                                                  | OF                   | CEN DF - 400pt                                         |     |
|                         |                       |                                                  |                                     |                                                     |                                |                                      |                                       | CEN RG - 2000M                             | RG                    | (Min)                      |                                                              | (Max)                                            | RG                   | CEN RG + 2000M                                         |     |
| Gun                     | Corr To<br>Burst Line | Oir Of<br>Corr<br>Toward<br>—BC—<br>Away<br>—BC— | (1)<br>Pos Lateral<br>Corr<br>(L/R) | (2)<br>100/R<br>GFT *<br>T<br>Min Rg<br>A<br>Max Rg | (3)<br>Pos Df<br>Corr<br>(L/R) | (4)<br>Btry<br>Comp<br>VE            | (5)<br>MV Unit<br>Corr Fac<br>(Tbl F) | (6)<br>MV Rg<br>Corr                       | (7)<br>Pos Rg<br>Corr | (8)<br>Total<br>Rg<br>Corr | (9)<br>P.s El Corr<br>(8) ÷ OR<br>Per Ipt<br>D El<br>(Tbl F) | (10)<br>Corr Rg<br>(8) ≈ 10M<br>Plus CEN<br>Rg * | (11)<br>Fs ~<br>(10) | (12)<br>Pos Ti<br>Corr<br>(11) Minus<br>Fs ~ CEN<br>Rg | Gun |
| #                       | #                     | T/A                                              | 5M                                  | 1pt                                                 | 1pt                            | 0.1M/S                               | 0.1 M                                 | 1M                                         | 5M                    | 1M                         | 1pt                                                          | 10M                                              | 0.1                  | 0.1                                                    | #   |
| 1                       |                       |                                                  | <i>L10</i>                          | <i>17</i>                                           | <i>L 2</i>                     | <i>I 1.3</i>                         | <i>-25.3</i>                          | <i>-33</i>                                 | <i>-130</i>           | <i>-163</i>                | <i>-15</i>                                                   |                                                  |                      |                                                        | 1   |
| 2                       |                       |                                                  | <i>L10</i>                          | <i>17</i>                                           | <i>L 2</i>                     | <i>D0.3</i>                          | <i>+32.4</i>                          | <i>+ 10</i>                                | <i>-90</i>            | <i>-80</i>                 | <i>- 7</i>                                                   |                                                  |                      |                                                        | 2   |
| 3                       |                       |                                                  | <i>R20</i>                          | <i>17</i>                                           | <i>R 3</i>                     | <i>0</i>                             | <i>—</i>                              | <i>0</i>                                   | <i>-10</i>            | <i>- 10</i>                | <i>- 1</i>                                                   |                                                  |                      |                                                        | 3   |
| 4                       |                       |                                                  | <i>R40</i>                          | <i>17</i>                                           | <i>R 7</i>                     | <i>D1.0</i>                          | <i>+32.4</i>                          | <i>+ 32</i>                                | <i>+40</i>            | <i>+ 72</i>                | <i>+ 7</i>                                                   |                                                  |                      |                                                        | 4   |
| 5                       |                       |                                                  | <i>R60</i>                          | <i>17</i>                                           | <i>R 10</i>                    | <i>D0.4</i>                          | <i>+32.4</i>                          | <i>+ 13</i>                                | <i>-15</i>            | <i>- 2</i>                 | <i>0</i>                                                     |                                                  |                      |                                                        | 5   |
| 6                       |                       |                                                  | <i>R85</i>                          | <i>17</i>                                           | <i>R 14</i>                    | <i>I0.2</i>                          | <i>-25.3</i>                          | <i>- 5</i>                                 | <i>-70</i>            | <i>- 75</i>                | <i>- 7</i>                                                   |                                                  |                      |                                                        | 6   |

Figure 8-42. Elevation correction.

(7) Add the total range correction expressed to the nearest 10 meters to the chart range to the target and record these values to the nearest 10 meters in column ⑩. Using the GFT, determine and record the fuze setting (under the Ti gageline) for the corresponding range in column ⑩, and record them in column ⑪. Using the GFT, determine and record the fuze setting for the chart range to the target in the heading of column ⑫. Perform the computations in the heading of column ⑫ and record these values in column ⑫ (fig 8-43) and in the FS Corr column of the Subsequent Fire

Commands block on the Record of Fire (fig 8-45).

*d. Answers:*

The completed forms for this special corrections problem are shown in figures 8-44 and 8-45. In the above Record of Fire, the ti, df, and el corrections are applied to the data determined for the center of the target and individual data for each piece is transmitted to the firing battery. When a correction is sent by the observer, the previously determined corrections are applied to the new data determined for the center of the target.

**REGISTRATION/SPECIAL CORRECTION WORKSHEET**

| REGISTRATION COMPUTATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |            |                         |           |             |                               |                     |                     |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------|-----------|-------------|-------------------------------|---------------------|---------------------|--|--|--------------------------------------------|---|-------|---|-------|---|-------|---|-----------------|------------|-------------------------|-----------|-------------|---------|--------|--------|--|-----|---|-----|-----|-----|---------------------|---------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|-----------------------------------------------------|--|--|--|
| ACHIEVED RANGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |            |                         |           |             | DEFLECTION CORRECTION         |                     |                     |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| 1 Chart Rg                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            | (10M)                   |           |             | 6 Corr Df (Reg)               |                     |                     |  |  | (1pt)                                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| 2 BP Displ (F/B +)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |            | (10M)                   |           |             | 5 BP Displ Corr (L + /R-)     |                     |                     |  |  | (1pt)                                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| 3 Achieved Rg (1+2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            | (10M)                   |           |             | 7 Adj Df (6 + 5)              |                     |                     |  |  | (1pt)                                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| BP DISPLACEMENT CORRECTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            |                         |           |             | 8 Chart Df                    |                     |                     |  |  | (1pt)                                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| 4 Lateral Displ (L/R)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |            | (5M)                    |           |             | 9 Total Df Corr (7-8) (+L/-R) |                     |                     |  |  | (1pt)                                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| 3 Achieved Rg                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |            | (10M)                   |           |             | 10 Drift Corr (~ Adj El) (L)  |                     |                     |  |  | (1pt)                                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| 5 BP Displ Corr (4÷3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |            | L/R                     |           |             | (1pt)                         |                     |                     |  |  | 11 GFT Df Corr (9-10)                      |   | (1pt) |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| GFT _____ Chg _____ Lot _____ Rg _____ El _____ Ti _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |            |                         |           |             |                               |                     |                     |  |  | DEFLECTION CORRECTION                      |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| GFT _____ Chg _____ Lot _____ Rg _____ El _____ Ti _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |            |                         |           |             |                               |                     |                     |  |  | Total                                      |   | GFT   |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| FADAC RESIDUALS Df ± _____ Fz ± _____ Rg K ± _____                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |            |                         |           |             |                               |                     |                     |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| TRANSFER OF GFT SETTING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |            |                         |           |             |                               |                     |                     |  |  | TERRAIN GUN POSITION / SPECIAL CORRECTIONS |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| <table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> <th>7</th> </tr> </thead> <tbody> <tr> <td>Btry</td> <td>Bn BP Comp</td> <td>MV Corr Factor D+ _____</td> <td>MVRg Corr</td> <td>Achieved Rg</td> <td>Corr Rg</td> <td>El ~ 5</td> <td>Ti ~ 5</td> </tr> <tr> <td></td> <td>M/S</td> <td>M</td> <td>10M</td> <td>10M</td> <td>10M</td> <td>Use EL Gage/line pt</td> <td>Use Ti Gage/line FS</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> |            |                         |           |             |                               |                     |                     |  |  |                                            | 1 | 2     | 3 | 4     | 5 | 6     | 7 | Btry            | Bn BP Comp | MV Corr Factor D+ _____ | MVRg Corr | Achieved Rg | Corr Rg | El ~ 5 | Ti ~ 5 |  | M/S | M | 10M | 10M | 10M | Use EL Gage/line pt | Use Ti Gage/line FS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | L/P/R Sector<br><b>TRANSFER LIMITS</b><br>Chg _____ |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1          | 2                       | 3         | 4           | 5                             | 6                   | 7                   |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
| Btry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Bn BP Comp | MV Corr Factor D+ _____ | MVRg Corr | Achieved Rg | Corr Rg                       | El ~ 5              | Ti ~ 5              |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | M/S        | M                       | 10M       | 10M         | 10M                           | Use EL Gage/line pt | Use Ti Gage/line FS |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                         |           |             |                               |                     |                     |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                         |           |             |                               |                     |                     |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                         |           |             |                               |                     |                     |  |  |                                            |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                         |           |             |                               |                     |                     |  |  | LEFT CENTER RIGHT                          |   |       |   |       |   |       |   |                 |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                         |           |             |                               |                     |                     |  |  | CEN DF+400pt                               |   | DF    |   |       |   | DF    |   | CEN DF-400pt    |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                         |           |             |                               |                     |                     |  |  | CEN RG-2000M                               |   | RG    |   | (Min) |   | (Max) |   | RG CEN RG+2000M |            |                         |           |             |         |        |        |  |     |   |     |     |     |                     |                     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                                     |  |  |  |

| Gun | # | Corr To Burst Line | Dir Df Corr Toward -BC Away -BC | 1                      | 2                                   | 3                 | 4            | 5                        | 6         | 7           | 8             | 9                                                | 10                                     | 11                                       | 12                                        | Gun |
|-----|---|--------------------|---------------------------------|------------------------|-------------------------------------|-------------------|--------------|--------------------------|-----------|-------------|---------------|--------------------------------------------------|----------------------------------------|------------------------------------------|-------------------------------------------|-----|
|     |   |                    |                                 | Pos Lateral Corr (L/R) | 100/R GFT *<br>T Min Rg<br>A Max Rg | Pos Df Corr (L/R) | Btry Comp VE | MV Unit Corr Fac (Tbl F) | MVRg Corr | Pos Rg Corr | Total Rg Corr | Pos El Corr<br>8 = DR<br>Per lpt D El<br>(Tbl F) | Corr Rg<br>8 ≈ 10M<br>Plus CEN<br>Rg * | Fs -<br>10<br>11 Minus<br>Fs - CEN<br>Rg | Pos Ti Corr<br>11 Minus<br>Fs - CEN<br>Rg |     |
|     | # | T/A                | 5M                              | 1pt                    | 1pt                                 | 0.1M/S            | D.1 M        | 1M                       | 5M        | 1M          | 1pt           | 10M                                              | 0.1                                    | 0.1                                      | #                                         |     |
| 1   |   |                    | L10                             | 17                     | L2                                  | I1.3 -25.3        | -33          | -130                     | -163      | -15         | 5870          | 228                                              | -0.8                                   | 1                                        |                                           |     |
| 2   |   |                    | L10                             | 17                     | L2                                  | D0.3 +32.4        | +10          | -90                      | -80       | -7          | 5950          | 232                                              | -0.4                                   | 2                                        |                                           |     |
| 3   |   |                    | R20                             | 17                     | R3                                  | 0                 | 0            | -10                      | -10       | -1          | 6020          | 235                                              | -0.1                                   | 3                                        |                                           |     |
| 4   |   |                    | R40                             | 17                     | R7                                  | D1.0 +32.4        | +32          | +40                      | +72       | +7          | 6100          | 240                                              | +0.4                                   | 4                                        |                                           |     |
| 5   |   |                    | R60                             | 17                     | R10                                 | D0.4 +32.4        | +13          | -15                      | -2        | 0           | 6030          | 236                                              | 0                                      | 5                                        |                                           |     |
| 6   |   |                    | R85                             | 17                     | R14                                 | I0.2 -25.3        | -5           | -70                      | -75       | -7          | 5950          | 232                                              | -0.4                                   | 6                                        |                                           |     |

DA FORM 4757

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FOR USE OF THIS FORM, SEE FM 6-40.

THE PROPONENT AGENCY IS TRADOC.

\* FOR SPECIAL CORR USE CHART RANGE TO TARGET

Figure 8-43. Time correction.

| FADAC RESIDUALS         |                             | Df ±                                             |                                 | Fz ±                                         |                         | Rg K ±                           |                                                       |                                            |                                      |                                |                                                            |                                                  |                                               |                                                     |     |
|-------------------------|-----------------------------|--------------------------------------------------|---------------------------------|----------------------------------------------|-------------------------|----------------------------------|-------------------------------------------------------|--------------------------------------------|--------------------------------------|--------------------------------|------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------|-----------------------------------------------------|-----|
| TRANSFER OF GFT SETTING |                             |                                                  |                                 |                                              |                         |                                  |                                                       | TERRAIN GUN POSITION / SPECIAL CORRECTIONS |                                      |                                |                                                            |                                                  |                                               |                                                     |     |
| Btry                    | ①                           | ②                                                | ③                               | ④                                            | ⑤                       | ⑥                                | ⑦                                                     | L/P/R Sector                               | TRANSFER LIMITS                      |                                |                                                            |                                                  | Chg                                           |                                                     |     |
|                         | Bn BP<br>Comp<br>VE         | MV Corr<br>Factor<br>D-<br>1-                    | MVRg<br>Corr<br>① × ② =         | Achieved<br>Rg<br>③ × ④ =                    | Corr<br>Rg<br>⑤ × ⑥ =   | El-<br>⑤<br>Use EL<br>(Gageline) | Ti-<br>⑦<br>Use Ti<br>(Gageline)                      |                                            |                                      |                                |                                                            |                                                  |                                               |                                                     |     |
|                         | M/S                         | M                                                | 10M                             | 10M                                          | 10M                     | pt                               | FS                                                    | LEFT CENTER RIGHT                          |                                      |                                |                                                            |                                                  |                                               |                                                     |     |
|                         |                             |                                                  |                                 |                                              |                         |                                  |                                                       | CEN DF+400pt                               | DF                                   |                                |                                                            | OF                                               | CEN DF-400pt                                  |                                                     |     |
|                         |                             |                                                  |                                 |                                              |                         |                                  |                                                       | CEN RG-2000M                               | RG                                   | (Min)                          |                                                            | (Max)                                            | RG                                            | CEN RG+2000M                                        |     |
| Gun                     | Corr<br>To<br>Burst<br>Line | Dir Of<br>Corr<br>Toward<br>-BC-<br>Away<br>-BC- | Pos<br>Lateral<br>Corr<br>(L/R) | 100/R<br>GFT *<br>T<br>Min Rg<br>A<br>Max Rg | Pos Df<br>Corr<br>(L/R) | Btry<br>Comp<br>VE<br>(I/D)      | MV Unit<br>Corr Fac<br>(Tb) F<br>0 + 32.4<br>1 - 26.3 | MV Rg<br>Corr<br>④ × ⑤                     | Pos Rg<br>Corr<br>(F = -)<br>(B = +) | Total<br>Rg<br>Corr<br>⑥ + ⑦ = | Pos El Corr<br>⑧ ÷ DR<br>Per lpt<br>D El<br>(Tb) F<br>(11) | Corr Rg<br>⑧ ≈ 10M<br>Plus CEN<br>Rg *<br>(6030) | Fs-<br>⑩<br>⑪ Minus<br>Fs-CEN<br>Rg<br>(23.6) | Pos Ti<br>Corr<br>⑪ Minus<br>Fs-CEN<br>Rg<br>(23.6) | Gun |
| #                       | #                           | T/A                                              | 5M                              | 1pt                                          | 1pt                     | 0.1M/S                           | 0.1 M                                                 | 1M                                         | 5M                                   | 1M                             | 1pt                                                        | 10M                                              | 0.1                                           | 0.1                                                 | #   |
| 1                       |                             |                                                  | L10                             | 17                                           | L2                      | I1.3                             | -25.3                                                 | -33                                        | -130                                 | -163                           | -15                                                        | 5870                                             | 22.8                                          | -0.8                                                | 1   |
| 2                       |                             |                                                  | L10                             | 17                                           | L2                      | D0.3                             | +32.4                                                 | +10                                        | -90                                  | -80                            | -7                                                         | 5950                                             | 23.2                                          | -0.4                                                | 2   |
| 3                       |                             |                                                  | R20                             | 17                                           | R3                      | 0                                | —                                                     | 0                                          | -10                                  | -10                            | -1                                                         | 6020                                             | 23.5                                          | -0.1                                                | 3   |
| 4                       |                             |                                                  | R40                             | 17                                           | R7                      | D1.0                             | +32.4                                                 | +32                                        | +40                                  | +72                            | +7                                                         | 6100                                             | 24.0                                          | +0.4                                                | 4   |
| 5                       |                             |                                                  | R60                             | 17                                           | R10                     | D0.4                             | +32.4                                                 | +13                                        | -15                                  | -2                             | 0                                                          | 6030                                             | 23.6                                          | 0                                                   | 5   |
| 6                       |                             |                                                  | R85                             | 17                                           | R14                     | I0.2                             | -25.3                                                 | -5                                         | -70                                  | -75                            | -7                                                         | 5950                                             | 23.2                                          | -0.4                                                | 6   |

Figure 8-44. Completed Registration/Special Correction Worksheet.

## RECORD OF FIRE

| Observer                                                     |          | CALL FOR FIRE |             | Tgt                      |            | TGT 387  |             | GFT R4          |             | △ FS         |             |           |     |     |     |      |
|--------------------------------------------------------------|----------|---------------|-------------|--------------------------|------------|----------|-------------|-----------------|-------------|--------------|-------------|-----------|-----|-----|-----|------|
| Grid: 6337 3862                                              |          | AR (FFS) S/S  |             |                          |            | BTRY 377 |             | DRIFT L9        |             | 100/R 17     |             |           |     |     |     |      |
| Polar: Dir                                                   |          | Dis           |             | U/D                      |            | VA       |             |                 |             | /R           |             |           |     |     |     |      |
| Shift                                                        |          | Dir           |             | L/R                      |            | U/D      |             |                 |             | 20/R 3       |             |           |     |     |     |      |
| INFANTRY IN TRENCH LINE, SAEAF 50X200 M, 800, VT             |          |               |             |                          |            |          |             |                 |             | HOB Corr +3  |             |           |     |     |     |      |
| FIRE ORDER FFE CANCEL TEAR CORR SPEC CORR SWEAF, FZ Ti ② AMC |          | Df Corr       |             | L5                       |            | Si       |             | +2              |             |              |             |           |     |     |     |      |
| INITIAL FIRE COMMANDS                                        |          | FM            |             | MF BTRY ②                |            | Rg 6030  |             | Cht Df 3450     |             | El 404       |             |           |     |     |     |      |
| Sp Instr AMC, CANCEL TEAR CORR, SPEC CORR                    |          | Sh            |             | Lot                      |            | Chg 4    |             | Fz Ti T(23.6)   |             | Df (3455)    |             |           |     |     |     |      |
| MTO H46 Ti ②                                                 |          | ④ T(300)      |             | PER                      |            | TF       |             | in Eff          |             | Ammo Exp ⑫ Q |             |           |     |     |     |      |
| Tgt                                                          | Location | Priority      | Firing Unit | SUBSEQUENT FIRE COMMANDS |            |          |             |                 |             |              |             |           |     |     |     |      |
| Dir, MF<br>Sh, Fz                                            | Dev      | Rg            | HOB<br>Corr | MF, Sh,<br>Chg, Fz       | FS<br>Corr | Ti       | Chart<br>Df | Df Corr<br>(LS) | Df<br>Fired | Chart<br>Rg  | HOB<br>Corr | Si<br>( ) | El  | QE  | Exp | Type |
|                                                              |          |               |             | * 1                      | -0.8       | 22.8     | L2          | 3457            |             |              |             |           | -15 | 394 |     |      |
|                                                              |          |               |             | * 2                      | -0.4       | 23.2     | L2          | 3457            |             |              |             |           | -7  | 402 |     |      |
|                                                              |          |               |             | * 3                      | -0.1       | 23.5     | R3          | 3452            |             |              |             |           | -1  | 408 |     |      |
|                                                              |          |               |             | * 4                      | +0.4       | 24.0     | R7          | 3448            |             |              |             |           | +7  | 416 |     |      |
|                                                              |          |               |             | * 5                      | 0          | 23.6     | R10         | 3445            |             |              |             |           | 0   | 409 |     |      |
|                                                              |          |               |             | * 6                      | -0.4       | 23.2     | R14         | 3441            |             |              |             |           | -7  | 402 |     |      |
| DIR 5800 +200 RPT                                            |          |               |             |                          |            |          |             |                 |             |              |             |           |     |     |     |      |
|                                                              |          |               |             | * 1                      | -0.8       | 23.8     | L2          | 3438            |             |              |             |           | -15 | 414 |     |      |
|                                                              |          |               |             | * 2                      | -0.4       | 24.2     | L2          | 3438            |             |              |             |           | -7  | 422 |     |      |
|                                                              |          |               |             | * 3                      | -0.1       | 24.5     | R3          | 3433            |             |              |             |           | -1  | 428 |     |      |
|                                                              |          |               |             | * 4                      | +0.4       | 25.0     | R7          | 3429            |             |              |             |           | +7  | 436 |     |      |
|                                                              |          |               |             | * 5                      | 0          | 24.6     | R10         | 3426            |             |              |             |           | 0   | 429 |     |      |
|                                                              |          |               |             | * 6                      | -0.4       | 24.2     | R14         | 3422            |             |              |             |           | -7  | 422 |     |      |
| Btry A DTG Tgt Replot Grid Replot Alt                        |          |               |             |                          |            |          |             |                 |             |              |             |           |     |     |     |      |

DA FORM 4504

1 Oct 78

REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

Figure 8-45. Completed Record of Fire.

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROponent AGENCY IS TRADOC

## Section V. FADAC

### 8-17. Hasty Traverse

For FADAC to provide firing data for open, converged, and special sheafs, the grid location of each weapon must be known. FADAC has the capability to determine the grid of each weapon in the battery using the same information needed to determine piece displacement with the plotting board and the hasty traverse technique. The procedure used with FADAC closely parallels the manual procedure using the plotting board in that the aiming circle is located first, and then each weapon is located with respect to the aiming circle. For the exact procedure on hasty traverse with FADAC, refer to the FADAC User's Manual.

### 8-18. Special Corrections

Once the grid of each weapon is known, it could be entered into FADAC as a firing unit. This allows computation of individual gun data to engage irregularly shaped targets. FADAC has the capability to store and compute data for only five firing units, while most

artillery batteries have six howitzers. Thus for light and medium batteries with six weapons, it is not practical to enter individual piece grid as a separate firing unit. For these units we will use platoon centers as firing units; i.e., right platoon as Battery A, center platoon as Battery B, left platoon as Battery C. This leaves the D and E Battery locations available for battery center and offset registration position, or an alternate or supplemental battery position, and special residuals such as ICM. Another option for the six-gun battery is to put weapon 1 in A Battery, weapon 2 in B Battery, base piece in C Battery (to be used for the center platoon), weapon 5 in D Battery, and weapon 6 in E Battery. For heavy batteries, it is recommended that each piece grid be entered as a separate firing unit; i.e., guns 1 through 4 entered in Batteries A through D. This leaves E Battery location available for an offset registration position or a supplementary or alternate battery position. For exact procedures on special corrections, refer to the FADAC User's Manual.



# CHAPTER 9

## HIGH ANGLE FIRE

### Section I. HIGH ANGLE AREA FIRE MISSIONS

#### 9-1. Description of High Angle Fire

a. High angle (HA) fire is fire delivered at elevations greater than the elevation corresponding to the maximum range for a charge. All howitzers are capable of delivering high angle fire effectively. High velocity weapons, such as guns, normally are not used for high angle fire because their high velocities result in extremely high maximum ordinates, long times of flight, and large probable errors. High angle fire is used for firing into or out of deep defilade, such as that found in heavily wooded areas, mountainous

areas, and cities. It may also be used to fire over high terrain features near friendly troops (fig 9-1). High angle fire may be requested by the observer based upon terrain in the target area. It may also be ordered by the FDO based upon the terrain in either the target area or the battery position.

b. Because high angle fire involves large quadrant elevations and long times of flight, it will not be as responsive as low angle fire in meeting the immediate needs of a maneuver force. Trajectories are vulnerable to enemy detection and the long time of flight makes it

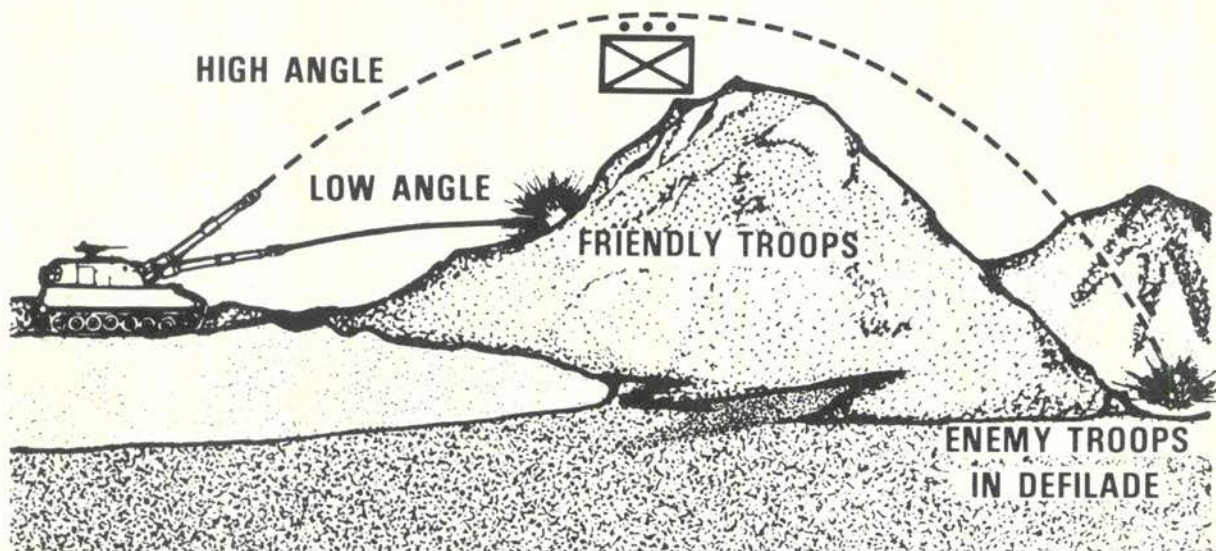


Figure 9-1. High angle fire.



difficult for the observer to identify his rounds. To assist the observer with this problem, the FDC will automatically announce **SPLASH** 5 seconds before the impact of each round. Splash is determined by subtracting 5 seconds from the time of flight (TOF). Because TOF may change drastically from round to round, it must be computed for each round during the adjustment. To further assist the FO, the FDC may announce time of flight in the Message to Observer. Time of flight will always be announced to air observer.

c. The principal characteristic of high angle fire is that *an increase in elevation will result in a decrease in range*.

d. Except for the differences noted in this chapter, procedures for high angle fire and low angle fire are the same. The duties of FDC personnel, in high angle fire, differ in several ways:

(1) The FDO will include the command **HIGH ANGLE** instead of charge in the fire order.

(2) The VCO will compute and announce **ANGLE OF SITE** rather than site.

(3) The computer will:

(a) Under the supervision of the FDO, select the charge to be fired.

(b) Include a drift correction in each deflection to be fired.

(c) If the fire order states **INCLUDE SITE**, compute the site and apply it to the elevation to determine the quadrant elevation to be fired.

## 9-2. Selection of Projectile and Fuze

a. The considerations discussed in appendix C for low angle fire generally apply to high angle fire. Both antipersonnel (AP) and dual purpose (DP) ICM can be employed in high angle fire for the same type targets as in low angle fire.

b. The high angle trajectory has two inherent characteristics that affect munitions selection: steep angle of fall and high terminal velocity. The steep angle of fall means the projectile is almost vertical as it

approaches the ground. When the projectile bursts, the side spray contains most of the fragmentation. Since in high angle fire the projectile is nearly vertical, the side spray is in all directions, nearly parallel to the ground, and little is absorbed by the ground (fig 9-2). Thus, shell HE, fuze Q is very effective when fired high angle. The high terminal velocity causes very large probable errors in height of burst for M564, fuze time.

### DO NOT FIRE FUZE TIME M564 IN HIGH ANGLE

Both the steep angle of fall and the high terminal velocity make shell HE fuze VT very effective for high angle fire as the side spray fragmentation effectiveness is increased.

## 9-3. Fire Order and Fire Commands

a. When high angle fire is to be used, the FDO will substitute the words **HIGH ANGLE** for charge in the fire order. The charge is determined by the computer. If high angle fire is requested by the forward observer, the FDO must still announce **HIGH ANGLE** in the fire order, unless **HIGH ANGLE** is in the fire order standards. If site is to be applied to the high angle elevation, the command **INCLUDE SITE** is included in the fire order.

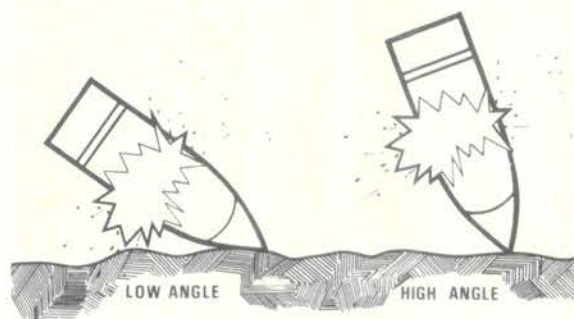


Figure 9-2. High angle vs. low angle side spray.

### Example:

The FDO of B Battery, a 155-mm, SP (M109A1) battery, has just received a call for fire on an infantry company in a ravine. The FO has requested high angle. The fire order standards and the fire order for this mission are shown in table 9-1.

Table 9-1. Fire Order Standards

| FIRE ORDER STANDARDS                                   |                       |
|--------------------------------------------------------|-----------------------|
| ELEMENT                                                | CURRENT STANDARD      |
| UNIT TO FIRE                                           | <b>BATTERY</b>        |
| ADJUSTING ELEMENT/METHOD OF FIRE OF ADJUSTING ELEMENT  | <b>#3 ①</b>           |
| BASIS FOR CORRECTIONS                                  | <b>FASTEST METHOD</b> |
| DISTRIBUTION                                           | <b>PARALLEL SHEAF</b> |
| PROJECTILE                                             | <b>HE</b>             |
| AMMUNITION LOT AND CHARGE                              | <b>SW/2</b>           |
| FUZE                                                   | <b>Q</b>              |
| NUMBER OF ROUNDS                                       | <b>①</b>              |
| RANGE SPREAD, LATERAL SPREAD, ZONE FIRE, OR SWEEP FIRE | <b>CENTER R6+DF</b>   |
| TIME OF OPENING FIRE                                   | <b>WHEN READY</b>     |

| FIRE COMMAND STANDARDS                         |                  |
|------------------------------------------------|------------------|
| ELEMENT                                        | CURRENT STANDARD |
| WARNING ORDER                                  |                  |
| PIECES TO FOLLOW/PIECES TO FIRE/METHOD OF FIRE | <b>#3 ①</b>      |
| SPECIAL INSTRUCTIONS                           |                  |
| PROJECTILE                                     | <b>HE</b>        |
| AMMUNITION LOT                                 | <b>SW</b>        |
| CHARGE                                         |                  |
| FUZE/FUZE SETTING                              | <b>Q</b>         |
| DIRECTION                                      |                  |
| QUADRANT ELEVATION                             |                  |
| METHOD OF FFE                                  |                  |

b. The fire commands for high angle include the command **HIGH ANGLE** to alert the guns that a high angle mission is to be fired. The computer, when sending the initial fire commands to the guns, will announce **HIGH ANGLE** in the special instructions element of the fire command.

#### 9-4. High Angle Graphical Firing Table

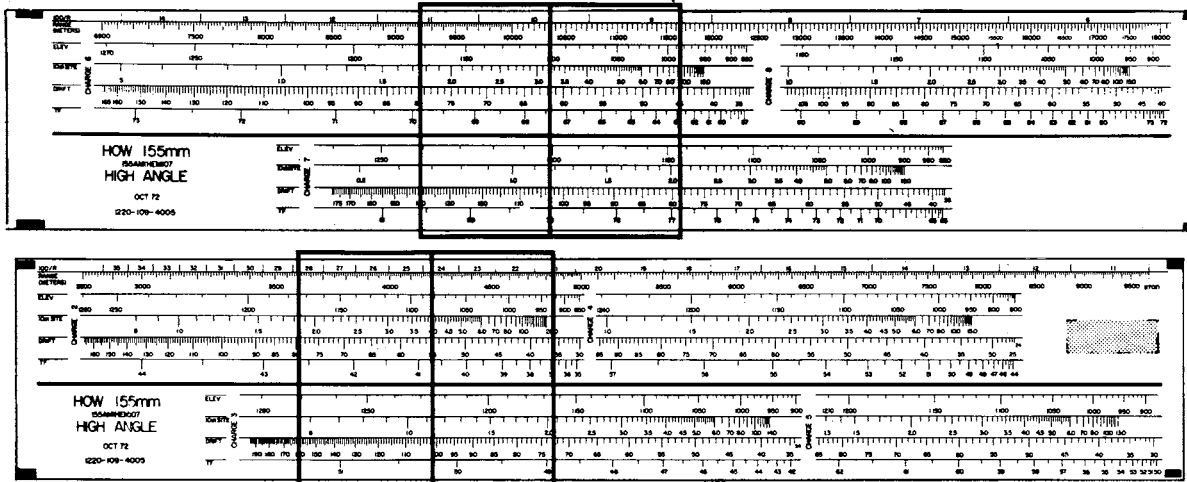
a. In high angle fire, as in low angle fire, the basic sources of ballistic data are the current tabular firing tables. To simplify the determination of firing data, FDC personnel may use the high angle GFT. The high angle GFT (fig 9-3) consists of one rule, with ballistic data for multiple charges on each

side. The scales on the high angle GFT, from top to bottom, are as follows:

- ★ (1) 100/R. The 100/R scale shows the number of mils necessary to move a burst left/right or up/down 100 meters at that range determined. The scale is read to the nearest mil.

(2) Range. The range scale is expressed logarithmically in meters and is applicable to all charges appearing on one side. Range increases from left to right and is read to the nearest 10 meters.

(3) Elevation. Elevation is expressed in mils and increases from right to left. It is read to the nearest mil.



High angle GFT.

(4) *10-mil site.* The values on the 10-mil site scale denote the site for each 10-mil angle of site for the elevation and charge selected. The numbers are printed in red and are negative. The scale increases from left to right and is read to the nearest tenth (0.1) of a mil.

(5) *Drift.* The values on the drift scale are in mils. Since the projectile always drifts to the right, the drift correction is applied to the left. The scale increases from right to left and is read to the nearest mil.

(6) *Time of flight.* The time of flight

scale is graduated in seconds and is used to determine both time of flight (nearest whole second) and VT fuze setting (to the next lower whole second).

b. Care must be taken in reading the high angle GFT because the scales increase in different directions. On the high angle GFT, the 100/R, elevation, drift, and time of flight scales increase from right to left. The range and 10-mil site scales increase from left to right. Shown in figure 9-4 is an aid that can be drawn on the cursor to help the computer read the scales correctly.

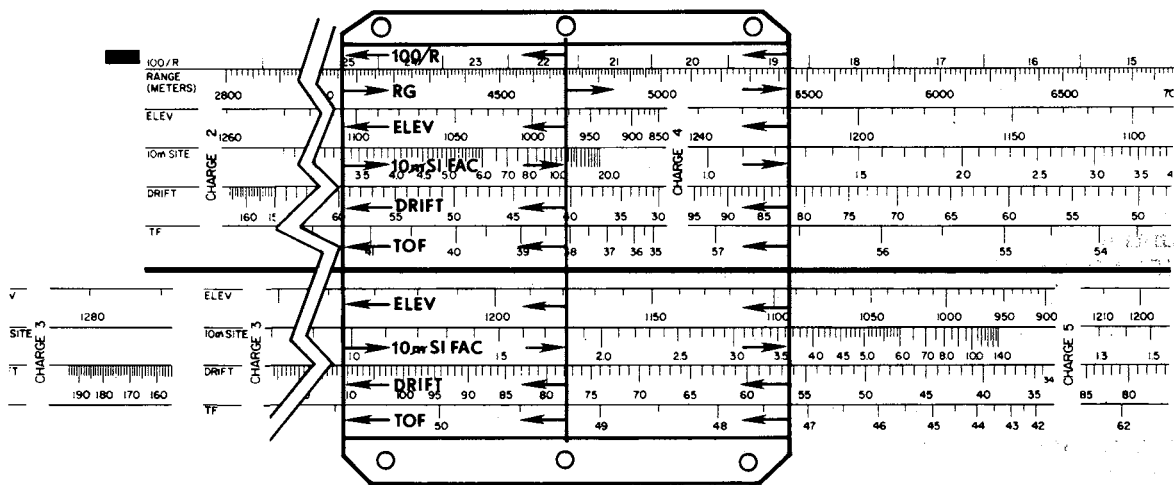


Figure 9-4. Aid for the reading of high angle scales.

**Example:**

Use figure 9-4 for charges 2 and 3 to determine the following information:

**Charge 2, Range 4700**

|                    |              |
|--------------------|--------------|
| 100/R              | 22 mils      |
| Elevation          | 972 mils     |
| 10-mil site factor | -11.2        |
| Drift              | L40          |
| Time of flight     | 38.1 seconds |

**Charge 3, Range 4700**

|                    |              |
|--------------------|--------------|
| 100/R              | 22 mils      |
| Elevation          | 1178 mils    |
| 10-mil site factor | -1.8         |
| Drift              | L78          |
| Time of flight     | 49.2 seconds |

**9-5. Selection of Charge**

High angle fire has two characteristics that affect the selection of charge: shorter range span for each charge and range overlap between charges.

a. The range span, within which accurate fires can be delivered by a particular charge, is less for high angle fire than low angle fire. This may cause a problem during a high angle fire mission because a large observer correction may move the round outside the capabilities of the initial charge fired. This will necessitate changing charges. Although changing charges during a high angle fire mission is sometimes unavoidable, it is not desirable. For this reason, the computer, supervised by the FDO, initially selects the charge that is least likely to require changing. As a guideline, he selects a charge that allows for a range shift of at least 500 meters short of and 500 meters beyond the initial chart range. For example, using GFT 155-AM-1 as shown in figure 9-4 and a chart range of 4700 meters, the computer selects charge 3 because charge 2 does not allow for a large observer correction.

b. High angle fire has a large degree of range overlap between charges. This characteristic usually gives the computer a choice between two or three charges. The computer selects a charge in accordance with

a above. If the computer still has a choice, then the lower charge is selected to reduce time of flight and tube wear.

**Example:**

The FDC for a 155-mm SP (M109A1) battery has received a fire mission that requires the use of high angle fire. The HCO announces a chart range of 8000 meters. Looking at the high angle GFT (155-AM-1), the computer has a choice between charge 4, charge 5, and charge 6. Initially, charge 4 is eliminated because it does not allow for an adequate range correction. Since both charges 5 and 6 allow for a large range change, charge 5 is selected because it is the lower charge.

**9-6. Site**

★ a. Although site has a relatively small effect because of the large angle of fall in high angle fire, site always is included in a registration, in a transfer mission (where GFT setting is transferred to nonregistering units or charges are changed during a fire mission), and in a mass mission. In other high angle missions, site is ignored if the angle of site is no larger than  $\pm 30$  mils. Since in high angle fire range decreases as elevation increases and range increases as elevation decreases, a minus site must be used to compensate for a plus vertical interval and a plus site must be used to compensate for a minus vertical interval.

b. If site is to be used, the FDO announces **INCLUDE SITE** in the fire order. Since one of the criteria for including site is an angle of site greater than  $\pm 30$  mils, the FDO may have to wait for the VCO to compute and announce angle of site. In this situation, the FDO issues a fire order and later supplements it with the command **INCLUDE SITE**.

**Example:**

In the example initiated in paragraph 9-3, the FDO did not know whether or not to include site and he issued the fire order without waiting: **HIGH ANGLE, FOUR ROUNDS, VT IN EFFECT.**

(1) The VCO computes angle of site. To do this, he uses the C and D scales of any GST. The angle of site has the same sign as the VI.

Btry B  
 Btry altitude 352  
 Target altitude 527  
 VI +175  
 Range 4700

VI Range Angle  
 (D scale) ÷ (C scale) = of site  
 +175 ÷ 4.7 = +38

(2) The VCO announces angle of site:

**ANGLE OF SITE BRAVO PLUS 38**

(3) Since the angle of site is greater than  $\pm 30$  mils, the FDO supplements the fire order with the command:

**INCLUDE SITE**

c. High angle site may be determined by using the TFT, or it may be determined by using the 10-mil site scale found on the high angle GFT (fig 9-4). Using the GFT is preferred. The readings obtained from the 10-mil site scale give the actual site for each 10 mils angle of site. The site is computed by multiplying the angle of site (divided by 10) by the 10-mil site factor. The 10-mil site factor is always negative and site is always opposite in sign to the angle of site.

$$\frac{\text{Angle of site}}{10} \times 10\text{-mil site factor} = \text{site}$$

*Example continued:* (fig 9-5)

Chg 3GB  
 Range 4700  
 Elevation 1178  
 Tgt alt 527  
 Btry alt 352  
 VI (527 - 352 = +175) +175  
 Angle of site (+175 ÷ 4.7 = +38) (GST) +38  
 10-Mil site factor (~el 1178) -1.8  
 Site (+38/10 × -1.8 = -6.84 = -7) -7

Quadrant elevation  
 (1178 + (-7) = 1171)

1171

|                     |    |                |      |
|---------------------|----|----------------|------|
| TGT ALT 527         |    | Δ FS           |      |
| BTRY ALT 352        |    | 100/R          |      |
| VI +175             |    | /R             |      |
| U/D 4 SI = +38      |    | 20/R           |      |
| +SI-10 +3.8         |    | 10 mil SI -1.8 |      |
| Df Corr L 78        |    | Si -7          |      |
| Rg 4700             |    | Chf Df 3294    |      |
| Chg 3 Fz TI         |    | Df 3372        |      |
| PE <sub>R</sub> TF  |    | ④ VT in Eff    |      |
| AMMO Exp            |    |                |      |
| QUANT FIRE COMMANDS |    |                |      |
| Corr                | Df | Chart          | HOB  |
| Fired               | Rg | Corr           | Si   |
|                     |    |                | El   |
|                     |    |                | QE   |
|                     |    |                | Exp  |
|                     |    |                | Type |

Figure 9-5. Site factor.

- ★ d. If a change in charge is required during the mission, site should be recomputed for the new charge.
- ★ e. Do not include HOB correction (20/R) when firing VT fuze in high angle.

### 9-7. Deflection and Drift

Drift is appreciably greater in high angle fire than in low angle fire. Because drift changes a great amount for a relatively small range change, a correction to compensate for drift is included in each deflection to be fired. Since drift is always to the right, the correction is applied to the left. The correction is determined from the high angle GFT and is added to the sum of the chart deflection and the GFT deflection correction (fig 9-6).

### 9-8. FADAC Procedures

The method of determining firing data in high angle missions is the same as low angle with the following exceptions:

- a. The FADAC operator enables the high angle function.
- b. The FADAC operator does not designate a charge.



## TOTAL DEFLECTION CORRECTION

| ELEVATION | ~ | RANGE | CHART<br>DEFLECTION | + | GFT<br>DEFLECTION<br>CORRECTION | + | DRIFT<br>CORRECTION | = | PIECE<br>DEFLECTION |
|-----------|---|-------|---------------------|---|---------------------------------|---|---------------------|---|---------------------|
| 1178      | ~ | 4700  | 3294                | + | 0                               | + | L78                 | = | 3372                |

Figure 9-6. Determination of high angle deflection.

## Section II. FDC PROCEDURES FOR HIGH ANGLE REGISTRATIONS

### 9-9. General

a. Based upon the considerations discussed in paragraph 9-1, it may become necessary to use high angle fire, instead of low angle fire, as the standard. In this situation, a high angle impact registration can be conducted to improve the accuracy of initial rounds. The use of the M564 MTSQ fuze to conduct a time registration is impractical because the height of burst probable error is so large.

- ★ b. When conducting a high angle impact registration, it is common for the range probable error to be equal to or greater than 25 meters. Since current high angle GFTs do not have a probable error in range gagepoint ( $\Delta$ ), the computer must check table G of the TFT to determine if the probable error in range is equal to or greater than 25 meters. A probable error in range gagepoint may be constructed on the high angle GFT for each charge. The gagepoint is marked on the time of flight scale.

c. Observed fire and fire direction procedures for high angle impact registrations are the same as low angle impact registrations contained in chapter 5 with three exceptions:

- (1) Due to the large complementary angle of site (comp site) in high angle fire, special procedures must be used to determine adjusted elevation.

(2) The high angle GFT setting is applied differently to the high angle GFT.

(3) High angle transfer limits are different from low angle transfer limits because the range of the various charges are smaller.

### 9-10. Computation of Adjusted Elevation

The adjusted elevation, determined from a high angle impact registration, often includes a false site. This false site is caused by the relationship of the comp site to total site. Comp site is a function of elevation. In low angle fire, small changes in elevation will cause small changes in comp site. On the other hand, in high angle fire, small changes in elevation will cause large changes in comp site. In a high angle registration, the comp site determined at the initial elevation and applied throughout the mission will often differ substantially from the comp site corresponding to the adjusted elevation. This false comp site, when added to the angle of site, will produce a false site. To provide accurate data, the FDC must determine the true site and subtract it from the adjusted QE to compute the true adjusted elevation. To determine the true site, successive approximation is used. The procedures for successive approximation follow.

- a. At the conclusion of a registration, the computer subtracts the site fired from the

[illegible]

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPONENT AGENCY IS TRADOC

adjusted QE to determine the first apparent elevation (fig 9-8).

Site fired -6

**b. The computer will then determine a new site by multiplying the angle of site  $\div 10$  by the 10-mil site factor corresponding to the first apparent elevation. This will yield a new site called the first apparent site. If the first apparent site agrees within 1 mil of the site fired, the first apparent site is the true site (fig 9-9).**

First apparent site  
 $(-3.7 \times +2.2 = 8.14 \approx -8)$  -8

c. If the first apparent site is not within 1 mil of the site fired, the computer will continue the same process. He will subtract the first apparent site from the adjusted QE to determine a second apparent elevation. He will use the 10-mil site factor corresponding to the second apparent elevation and the angle of site to compute a second apparent site. If the second apparent site is within 1 mil of the previously computed site, the second apparent site is the true site.

d. If the second apparent site is not within 1 mil of the previously computed site, the computer will continue the process until the last computed site is within 1 mil of the previously computed site. *The last site*



10th SI FAC  $(-3.7) \times (+2.2) = -8$  (1st APP SI)

Figure 9-8. Determination of first apparent site.

|               |                 |                                                                 |
|---------------|-----------------|-----------------------------------------------------------------|
| ADJ QE        | 1084            |                                                                 |
| -Si FIRED     | <del>(-6)</del> |                                                                 |
| 1ST APP EL    | 1090            | $10\text{M Si } (-3.7) \times (+2.2) = -8 \text{ (1ST APP Si)}$ |
| ADJ QE        | 1084            |                                                                 |
| -1ST APP Si - | <del>(-8)</del> |                                                                 |
| 2ND APP EL    | 1092            | $10\text{M Si } (-3.7) \times (2.2) = -8 \text{ (TRUE Si)}$     |

Figure 9-9. First apparent site is not true site.

*computed is the true site (fig 9-10).*

*Example continued:*

**Second apparent elevation**  
(1084 -(-8) = 1092) 1092

10-mil site factor ~ EL 1092                      -3.7

Second apparent site  
 $(-3.7 \times -2.2 = -8.14 \approx -8)$  -8

*Note.* Second apparent site (-8) is within 1 mil of the previous site computed (-8).

- e. The computer will subtract the true site from the adjusted QE to compute the true adjusted elevation.

*Example continued:*

Adjusted QE 1084

True site -8

Adjusted elevation

$$(1084 - (-8) = 1092) \qquad 1092$$
[illegible]

|              |             |     |
|--------------|-------------|-----|
| Tgt REG PT 2 | Replot Grid | Rep |
|--------------|-------------|-----|

Figure 9-10. The last site computed is the true site.

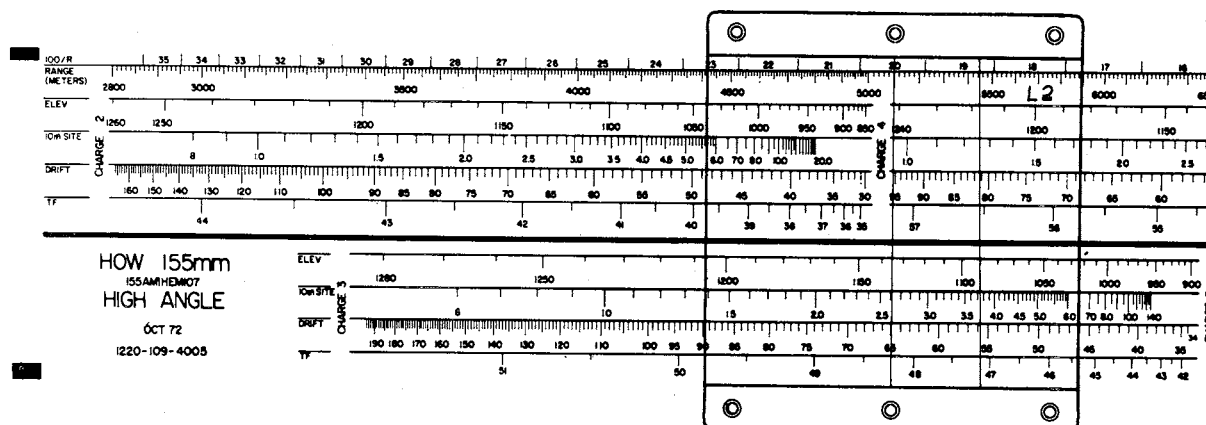


Figure 9-11. Construction of a high angle GFT setting.

### 9-11. High Angle GFT Setting

a. GFT settings for high angle fire are written in the same manner as those for low angle fire. For the example in the previous paragraph, the GFT setting is GFT B: Chg 3, Lot SW, Rg 5100, El 1092, GFT Df Corr L2.

b. The high angle GFT setting is constructed on the GFT by placing the hairline over the adjusted elevation for the charge and drawing a range gageline through the GFT setting range on the range scale (fig 9-11). The hairline becomes the elevation gageline and all data except range and 100/R are read under the hairline. The GFT deflection correction and charge are recorded on the cursor.

GFT B: Chg 3, Lot SW, Rg 5100, El 1092; GFT Df Corr L2.

### 9-12. High Angle Transfer Limits

Standard range transfer limits are not applicable to high angle fire because the range span of each charge is so short. Corrections in the form of GFT settings and GFT deflection corrections are considered valid for the charge used in determining the corrections and are considered valid for other charges as shown in table 9-2.

### 9-13. Massing and Transfers

a. The high maximum ordinate and long time of flight encountered in high angle fire

make massing or transferring with high angle fire less reliable than with low angle fire. However, under stable weather conditions, successful transfers of fire within a single charge are practical. Every effort should be made to obtain observation and to adjust each battery that is to fire on the target.

b. When several batteries are to mass on a target and only one battery is to adjust, site should be computed at the initial range for each battery. Site should be recomputed for the nonadjusting batteries whenever it is necessary to recompute site for the adjusting battery (e.g., when the adjusting battery changes charges); site should also be recomputed for an individual nonadjusting battery when it changes charges.

c. During an adjustment, the 10-mil site factor may change considerably. This change will result at the end of the adjustment in a site that differs from that used in the initial commands. However, the error in range caused by the false site for the adjusting battery will be essentially the same range error required to compensate for the false sites of the nonadjusting batteries.

d. When adjusting is required before massing the battalion and when only one battery is to adjust, the battery that is most centrally located should normally be

★ Table 9-2. Transfer Limits

**TRANSFER LIMITS, HIGH ANGLE**

| WEAPON                                          | CHARGE<br>REGISTERED<br>WITH | TRANSFER LIMITS                                                                                                                                                                                                                                              |
|-------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 105-MM HOW                                      | 1,2,3,4,5,<br>6<br>7         | ALL RANGES, CHARGES 1 THROUGH 5<br>CHARGE 6 ONLY $\pm 1500$ METERS<br>CHARGE 7 ONLY $\pm 1500$ METERS*                                                                                                                                                       |
| 155-MM HOW<br>AND 8-INCH HOW                    | 1,2,3,4,<br>5<br>6<br>7      | ALL RANGES, CHARGES 1 THROUGH 5<br>CHARGE 5, $\pm 1$ CHARGE IN SAME<br>PROPELLANT TYPE $\pm 1500$ METERS<br>CHARGE 6, $\pm 1$ CHARGE IN SAME<br>PROPELLANT TYPE $\pm 1500$ METERS*<br>CHARGE 7, $\pm 1$ CHARGE IN SAME<br>PROPELLANT TYPE $\pm 1500$ METERS* |
| 155-MM HOW<br>(M109A1) AND 8-INCH HOW<br>M110A1 | 8<br>9                       | CHARGE 8, $\pm 1$ CHARGE IN SAME<br>PROPELLANT TYPE $\pm 1500$ METERS*<br>CHARGES 8 AND 9 (M188 SERIES ONLY)<br>$\pm 1500$ METERS                                                                                                                            |

\* $\pm 2,000$  METERS FOR REGISTRATION POINT RANGES GREATER THAN 10,000 METERS

Note. Transfers within propellants apply to only green bag or white bag.

designated as the adjusting battery to eliminate large differences in range.

#### ★ 9-14. DPICM Registration

a. The DPICM (M483A1) projectile may be fired as a normal ICM round, or it may be fired in the registration mode that destroys the bomblets.

b. If terrain in the target and/or battery area indicates high angle fire must be used, a high angle, high burst registration can be conducted using the M577 or M724 fuze (each has a small HOB probable error). This type of registration is conducted with the DPICM projectile in the self-registration mode. The procedures are the same as those for a low angle HB registration with the following exceptions (fig 9-12).

(1) A minimum of 2 PEHB (table G, TFT) or 50 meters is added to the orienting point ground altitude.

(2) Since large VIs are possible in an HB, HA registration, the fuze setting to fire is the fuze setting corresponding to elevation plus comp site if the VI exceeds 100 meters. With large VIs, comp site in high angle fire will be a relatively large negative number. Comp site is determined by entering the TFT, table G, column 12 (unless the angle of site is  $-30$  mils or greater; then use column 13) to the nearest 100 meters in range listed and extracting the comp site factor for a 1-mil angle of site. Multiply the angle of site by this comp site factor. The result is comp site. Apply the comp site to the elevation determined from the HA GFT. Determine the fuze setting by placing the MHL on the HA GFT over the

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value of EL + CAS and reading from the TF scale the time to the nearest 0.1 FS increment.

registration. The adjusted time is used to determine a total fuze correction, which is applied to the fuze setting corresponding to the the adjusted elevation when firing with a GFT setting. In solving concurrent met to determine position constants, the total fuze correction is used as a known correction.

## 9-15. FADAC Procedures for Registration

a. The operator procedures for determining adjusted data during the conduct of a high angle impact registration are no different from those for a low angle registration. The operator determines an adjusted deflection and adjusted quadrant, but not an adjusted time since a time registration is not conducted with high angle fire using the M564 MTSQ fuze.

*d.* The adjusted time is determined in the same manner as for a low angle HB

| HIGH BURST (MEAN POINT OF IMPACT) REGISTRATION                                                    |      |         |      |                      |                 |         |                            |                                 |      |  |
|---------------------------------------------------------------------------------------------------|------|---------|------|----------------------|-----------------|---------|----------------------------|---------------------------------|------|--|
| For use of this form, see FM 6-40: the proponent agency is US Army Training and Doctrine Command. |      |         |      |                      |                 |         |                            |                                 |      |  |
| COMPUTATION OF HB (MPI) LOCATION                                                                  |      |         |      |                      |                 |         |                            |                                 |      |  |
| Message to Observers                                                                              |      |         |      |                      | Dis<br>OI → O2  |         | Az O1 → O2                 |                                 | 1569 |  |
| OBS HA, HB REGISTRATION                                                                           |      |         |      |                      |                 |         | Az O2 → O1                 |                                 | 4769 |  |
| OI DIR 0679, VA +12                                                                               |      |         |      |                      |                 |         | 3200                       |                                 |      |  |
| MEASURE THE VA                                                                                    |      |         |      |                      |                 |         |                            |                                 |      |  |
| O2 DIR 6152, VA +9                                                                                |      |         |      |                      |                 |         |                            |                                 |      |  |
| REPORT WHEN READY TO OBS                                                                          |      |         |      |                      | 4262.8          |         |                            |                                 |      |  |
| Data Fired                                                                                        |      | Chg 4GB |      | Dt 2815              |                 | FS 52.8 |                            | QE 1146                         |      |  |
| Observer Readings                                                                                 |      |         |      |                      | Interior Angles |         |                            |                                 |      |  |
| Rd                                                                                                | O1   | VA      | O2   | OI on Left           |                 |         | OI on Right                |                                 |      |  |
| No                                                                                                | Az   |         | Az   |                      |                 |         |                            |                                 |      |  |
| 1                                                                                                 | 0692 | 13      | 6163 | Az O1 → HB (MPI)     |                 |         | Az O2 → HB (MPI)           |                                 |      |  |
| 2                                                                                                 | 0687 | 14      | 6159 | +6400 if necessary   |                 |         | +6400 if necessary         |                                 |      |  |
| 3                                                                                                 | 0694 | 15      | 6160 | Total                |                 |         | Total                      |                                 |      |  |
| 4                                                                                                 | 0685 | 13      | 6157 | -Az O2 → HB (MPI)    |                 |         | -Az O1 → HB (MPI)          |                                 |      |  |
| 5                                                                                                 | 0689 | 15      | 6159 | APEX 4               |                 |         | APEX 4                     |                                 |      |  |
| 6                                                                                                 | 0687 | 14      | 6162 | Az O2 → HB (MPI)     |                 |         | Az O2 → O1                 |                                 |      |  |
| 7                                                                                                 |      |         |      | +6400 if necessary   |                 |         | +6400 if necessary         |                                 |      |  |
| 8                                                                                                 |      |         |      | Total                |                 |         | Total                      |                                 |      |  |
| 9                                                                                                 |      |         |      | -Az O2 → O1          |                 |         | -Az O2 → HB (MPI)          |                                 |      |  |
| 10                                                                                                |      |         |      | Az at O2             |                 |         | Az at O2                   |                                 |      |  |
| 4134                                                                                              |      |         |      | 36960                |                 |         | Total                      |                                 |      |  |
| 0689                                                                                              |      |         |      | 6160                 |                 |         | Average                    |                                 |      |  |
| Distance O1 HB (MPI)                                                                              |      |         |      |                      |                 |         |                            |                                 |      |  |
| Log base O1 → O2                                                                                  |      |         |      | 4262.8               |                 |         | 3.629695                   |                                 |      |  |
| +Log sin Az at O2                                                                                 |      |         |      | 1391                 |                 |         | 9.990793                   |                                 |      |  |
| Sum                                                                                               |      |         |      |                      |                 |         | 3.620488                   |                                 |      |  |
| -Log sin Apex Angle                                                                               |      |         |      | 929                  |                 |         | 9.898043                   |                                 |      |  |
| diff = Log dist O1 HB (MPI)                                                                       |      |         |      | 3.722445             |                 |         | dE - dN -                  |                                 |      |  |
| Dist O1 → HB (MPI)                                                                                |      |         |      | (5277.7)             |                 |         | Bearing = Az - 3200        |                                 |      |  |
|                                                                                                   |      |         |      | 52.78                |                 |         | Bearing = Az               |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | dE + dN +                  |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | Az O1 → HB (MPI) - Bearing |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | 0689                       |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | Bearing                    |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | N0689E                     |                                 |      |  |
| Log of dE, dN, and dH                                                                             |      |         |      |                      |                 |         |                            |                                 |      |  |
| Log dist O1 → HB (MPI)                                                                            |      |         |      | 3.722445             |                 |         | Log dist O1 → HB (MPI)     |                                 |      |  |
| Log sin Bearing                                                                                   |      |         |      | 9.796580             |                 |         | Log sin Bearing            |                                 |      |  |
| Sum = Log dE                                                                                      |      |         |      | 3.519025             |                 |         | Sum = Log dN               |                                 |      |  |
| Coordinates of O1                                                                                 |      |         |      | E 59.7643            |                 |         | N 33.8718                  |                                 |      |  |
|                                                                                                   |      |         |      | dE 3.3039            |                 |         | dN 4.1156                  |                                 |      |  |
| Location of HB (MPI)                                                                              |      |         |      | E 63.0682            |                 |         | N 37.9874                  |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | H 358.3                    |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | H 72.5                     |                                 |      |  |
|                                                                                                   |      |         |      |                      |                 |         | H 430.8                    |                                 |      |  |
| COMPUTATION OF GFT SETTING                                                                        |      |         |      |                      |                 |         |                            |                                 |      |  |
| Alt HB (MPI)                                                                                      |      | 431     |      | QE fired             |                 | 1146    |                            | Chart data to HB (MPI) location |      |  |
| -Alt Btry                                                                                         |      | 369     |      | -Site VI/HB (MPI) Rg |                 | -3      |                            | Deflection 2752                 |      |  |
| VI                                                                                                |      | 62      |      | Adj Elev             |                 | 1149    |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Charge 4                        |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Lot MV                          |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Elevation 1149                  |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Time                            |      |  |
|                                                                                                   |      |         |      |                      |                 |         |                            | Range 5780                      |      |  |
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| </                                                                                                |      |         |      |                      |                 |         |                            |                                 |      |  |

## C1, FM 6-40

b. Determining high angle residuals is the same as determining low angle residuals, with the following exceptions:

(1) The FADAC operator enables the high angle function.

(2) Only an adjusted deflection and adjusted quadrant are entered.

(3) Residuals can be stored for the charge used and for other transferable charges.

(4) Since the registration corrections were determined by means of high angle fire, the corrections will not automatically be applied by FADAC when determining low

angle firing data. FADAC is capable of storing only one set of registration corrections per charge.

c. The FADAC derived GFT setting is simply the association of an achieved range with the FADAC elevation at that range. A derived GFT setting should be determined at the ranges shown in table 9-3. The center range for charge 3 is the optimum range to use in deriving a GFT setting if you desire a GFT setting that will transfer charges 1 through 5. If the tactical situation permits the firing on only charges 3 through 5, select the center range for charge 4 to derive the GFT setting.

Table 9-3. High Angle Registration Charges

### HIGH ANGLE TRANSFER LIMITS

| ★ |                                               |                        |                                 |
|---|-----------------------------------------------|------------------------|---------------------------------|
|   | WEAPON                                        | CENTER RANGE<br>CHARGE | TRANSFER LIMITS                 |
|   | 105-MM, 155-MM,<br>AND 8-INCH HOW             | 3                      | ALL RANGES, CHARGES 1 THROUGH 5 |
|   | 105-MM, 155-MM<br>AND 8-INCH HOW              | 6                      | CHARGE 6 ONLY                   |
|   | 105-MM, 155-MM<br>AND 8-INCH HOW              | 7                      | CHARGE 7 ONLY                   |
|   | 155-MM M109A1 HOW<br>AND 8-INCH HOW<br>M110A1 | 8                      | CHARGE 8 ONLY                   |

# CHAPTER 10

## REPLOT DATA

### Section I. MANUAL PROCEDURES

In many instances fire for effect or refined FFE data may not reflect the actual location of the target as defined by its chart coordinates and altitude. This inaccuracy results from errors in initial target location and errors in determining the initial site fired in an adjust fire mission. For the observer to be able to accurately shift from a known point located by replot, or for other units to mass fires on the same point, it is essential that the actual target location and altitude be determined as accurately as possible. To accomplish this, the replot process is used. Replot gives a deflection and range with which the actual target location can be polar

plotted from the chart location of the firing battery. The replot procedures for PD and VT fuzes are essentially the same; the procedures for time fuze are somewhat different. Targets are replotted on request of the observer or when directed by the FDO.

#### 10-1. Reason for Replot

a. Many times an observer is unable to locate a target accurately. Inaccurate target location may result in an inaccurate altitude and an inaccurate site being determined by the FDC. If the observer has located a target at a higher altitude than the altitude where it

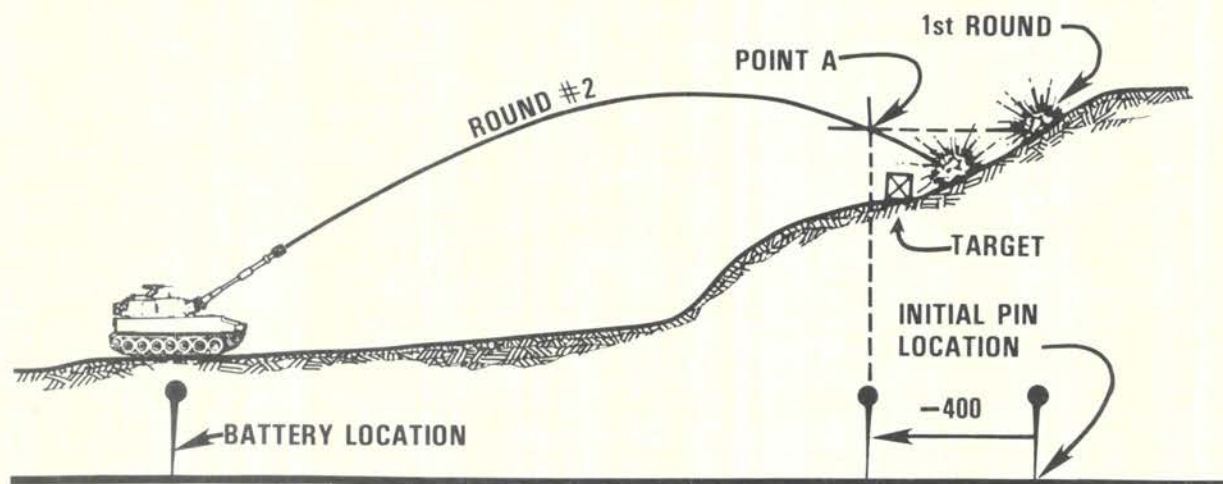


Figure 10-1. Second target location.



actually is the site would be determined based on an incorrect altitude. The observer sends a correction of DROP 400. The data is computed to impact at point A (fig 10-1) because no adjustment has been made to altitude. The projectile continues and impacts over the target. In figure 10-2, it can be seen that with the observer's next correction (DROP 50) accurate fire for effect is obtained. It can also be seen that there is a difference between the final pin location on the firing chart and the actual target location.

b. Replot procedures use successive approximation to determine the true site and the actual (replot) range and deflection to the target.

### 10-2. Requirements for Replot

To replot a target accurately, the FDC needs accurate refinement data from the observer, a map, and a valid GFT setting. A valid GFT setting is one that accurately portrays the corrections for nonstandard conditions at the time the mission was fired. This GFT setting may not be the GFT setting used to fire the mission as an outdated GFT setting may have been used. If a valid GFT setting for the time of firing is determined, it is used in

replotting the target.

### 10-3. Replot with PD and VT Fuzes

a. *Replot Deflection.* The replot (true) deflection to the target may or may not be the final piece deflection. Because drift may have changed during the conduct of the adjustment, the true total deflection correction is determined as follows:

(1) Determine the first apparent elevation. The first apparent elevation is the elevation corresponding to the chart range to the final pin location.

(2) Determine drift corresponding to the first apparent elevation.

(3) Add the drift determined as in (2) above to the GFT deflection correction. This yields the true total deflection correction. The replot deflection is then determined by subtracting the true total deflection correction from the final piece deflection.

b. *Replot Grid and Altitude.* The replot grid and altitude are determined by successive approximation. The procedures are described below.

(1) The battery computer subtracts site from the final quadrant to determine the first

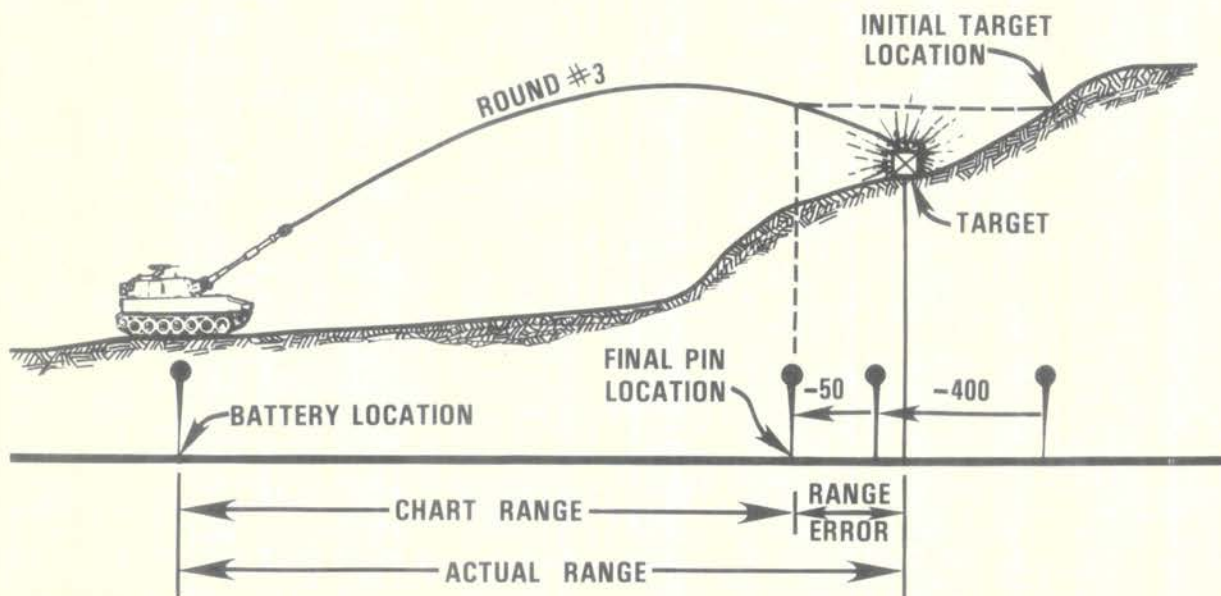


Figure 10-2. Observer's final correction.



apparent elevation. The computer determines the replot deflection as outlined in *a* above and announces it to the HCO. He then determines the range corresponding to the first apparent elevation. This is the range read under the manufacturer's hairline when the elevation gageline is placed on the first apparent elevation. This range is announced to the HCO.

(2) The HCO polar plots the target from the battery center at the deflection and range announced by the computer and announces the plotted grid to the VCO.

(3) The VCO plots the grid and determines the map altitude at the replotted location. Using the new altitude and the range last announced by the computer, the VCO computes the first apparent site and announces it to the computer.

(4) The computer determines if the first apparent site is within  $\pm 1$  mil of the last computed site.

(a) If the first apparent site is within  $\pm 1$  mil of last computed site, the site is

considered true site. The computer subtracts the true site from the final quadrant to determine true elevation. Using the procedure described in (1) above, the computer determines the replot range. The replot deflection remains the same throughout the process of successive approximation. The computer announces the replot deflection and range to the HCO. The HCO polar plots the data and announces the final replot grid to the VCO. The VCO announces the altitude used to determine true site.

(b) If the site is not within  $\pm 1$  mil of the last computed site, the steps in (1)—(3) above are repeated until a true site is determined that agrees within  $\pm 1$  mil of the last site determined.

*Example:*

Given: M109A1 (FT 155-AM-1).

GFT B: Chg 4, Lot WT, Rg 5270, El 350, Ti 19.9

Tot Df Corr L6; GFT Df Corr R2

Completed Record of Fire in figure 10-3.

*Solution:*

| STEP | COMPUTER                                                                                                                                                                                                                                             | HCO | VCO |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|
| 1    | Determines first apparent elevation. Final QE -<br>site fired = $373 - (-11) =$<br>384.                                                                                                                                                              |     |     |
| 2    | Determines replot deflection.<br>GFT deflection correction R2<br>Drift corresponding to first<br>apparent elevation ..... L8<br>True total deflection _____<br>correction ..... L6<br>Final piece deflection .. 3214<br>Replot deflection ..... 3208 |     |     |
| ★ 3  | Determines range.<br>Range corresponding to<br>first apparent<br>elevation 384 = 5630.                                                                                                                                                               |     |     |

## RECORD OF FIRE

|                                                                                                              |  |                                    |  |                |  |                                                          |  |                                              |  |
|--------------------------------------------------------------------------------------------------------------|--|------------------------------------|--|----------------|--|----------------------------------------------------------|--|----------------------------------------------|--|
| Observer <b>B21</b>                                                                                          |  | CALL FOR FIRE<br><b>ADFFE/IS/S</b> |  | Tgt            |  | REG PT2 ALT 355 GFT R2<br>BTRY ALT 405 DFT L7<br>VI - 50 |  | △ PS<br>100/R 20<br>/R<br>20/R 4<br>HOB Corr |  |
| Grid:                                                                                                        |  | Polar: Dir                         |  | Dis            |  | U/D                                                      |  | VA                                           |  |
| Shift                                                                                                        |  | REG PT2                            |  | Dir            |  | 600                                                      |  | 200                                          |  |
| MG IN TREE LINE                                                                                              |  | U/D                                |  | 200            |  | U/D                                                      |  |                                              |  |
| FIRE ORDER <b>(2)</b>                                                                                        |  | INITIAL FIRE COMMANDS              |  | MF BTRY ADJ    |  | Rg 5100                                                  |  | Df Corr L5                                   |  |
| Sp Instr                                                                                                     |  | Sh                                 |  | Lot            |  | Chg 4                                                    |  | Fz                                           |  |
| MTO 447, <b>(2)</b>                                                                                          |  | T                                  |  | PER            |  | TF                                                       |  | <b>(2)</b> in Eff                            |  |
| Tgt                                                                                                          |  | Location                           |  | Priority       |  | Firing Unit                                              |  | HOB Corr                                     |  |
| Dir, MF                                                                                                      |  | Dev                                |  | Rg             |  | MF, Sh, Chg, Fz                                          |  | PS Corr                                      |  |
| Sh, Fz                                                                                                       |  | Rg                                 |  | HOB Corr       |  | PS Corr                                                  |  | Ti                                           |  |
| Chart Df                                                                                                     |  | Df Corr (L5)                       |  | Df Fired       |  | Chart Rg                                                 |  | HOB Corr                                     |  |
| Si                                                                                                           |  | Si (11)                            |  | EI             |  | QE                                                       |  | Exp                                          |  |
| Type                                                                                                         |  |                                    |  |                |  |                                                          |  |                                              |  |
| R50                                                                                                          |  | +600                               |  |                |  | 3214                                                     |  | L5 3219 5760                                 |  |
| R30                                                                                                          |  | -50FFE                             |  | BTRY (2)       |  | 3208                                                     |  | L5 3213 5590                                 |  |
| L10                                                                                                          |  | +10 REC                            |  | EM             |  | 3209                                                     |  | L5 (3214) 5640                               |  |
| AS TGT, EM                                                                                                   |  |                                    |  |                |  |                                                          |  |                                              |  |
| (THE FOLLOWING IS THE SEQUENCE OF STEPS NOT ON THE ROF)                                                      |  |                                    |  |                |  |                                                          |  |                                              |  |
| CMPT TO HCO                                                                                                  |  | REPLAT DF 3208                     |  | REPLAT RG 5630 |  | 1 APP EL (384)                                           |  |                                              |  |
| HCO TO VCO                                                                                                   |  | REPLAT GRID 4371 3421              |  |                |  |                                                          |  |                                              |  |
| VCO TO CMPT                                                                                                  |  | (ALT 366) SITE B -8                |  |                |  |                                                          |  |                                              |  |
| CMPT TO HCO                                                                                                  |  | REPLAT DF 3208                     |  | REPLAT RG 5610 |  | 2 APP EL (373 - (-8) = 381)                              |  |                                              |  |
| HCO TO VCO                                                                                                   |  | REPLAT GRID 4374 3417              |  |                |  |                                                          |  |                                              |  |
| VCO TO CMPT                                                                                                  |  | (ALT 371) SITE B -7                |  |                |  |                                                          |  |                                              |  |
| CMPT TO HCO                                                                                                  |  | REPLAT DF 3208                     |  | REPLAT RG 5590 |  | 3 APP EL (373 - (-8) = 380)                              |  |                                              |  |
| HCO TO CMPT                                                                                                  |  | REPLAT GRID 4373 3416              |  |                |  |                                                          |  |                                              |  |
| VCO TO CMPT                                                                                                  |  | REPLAT ALT 373                     |  |                |  |                                                          |  |                                              |  |
| Btry <b>B</b> DTG <b>121300 JUL 80</b> Tgt <b>AG 6347</b> Replot Grid <b>4373 3416</b> Replot Alt <b>373</b> |  |                                    |  |                |  |                                                          |  |                                              |  |

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Figure 10-3. Completed Record of Fire—PD fuze.

STEP                      COMPUTER                      HCO                      VCO

4 Announces: Polar plots grid.

REPLOTT

DEFLECTION ..... 3208

RANGE ..... 5630

Measures and  
announces grid to  
VCO:  
GRID 43713421

Plots grid.

Determines altitude.  
Altitude 366.  
Determines vertical interval.  
VI = 366 - 405 = -39.  
Computes first  
apparent site.  
GST -39/5630(TBG)  
First apparent site = -8.  
Announces to computer:  
SITE BRAVO MINUS 8.

| STEP | COMPUTER                                                                                                                                                             | HCO                                                                                                                                                                    | VCO                                                                                                                                                                     |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5    | Determines that site does not agree within $\pm 1$ mil.<br>Determines second apparent elevation.<br>QE - first apparent site<br>$373 - (-8) = 381$ .                 |                                                                                                                                                                        |                                                                                                                                                                         |
| ★ 6  | Determines range corresponding to second apparent elevation $381 = 5610$ .<br>Announces:<br>REPLOT<br>DEFLECTION ..... 3208<br>RANGE ..... 5600                      | Polar plots data and announces location: REPLOT<br>GRID 43743417.                                                                                                      | Plots replot grid and computes second apparent site.<br>$VI = 371 - 405 = -34$<br>$GST -34/5600 = -7$<br>Second apparent site = -7.<br>Announces:<br>SITE BRAVO MINUS 7 |
| ★ 7  | Determines that the site determined is within $\pm 1$ mil of previous site; it is the true site. Determines true elevation.<br>QE - true site = $373 - (-7) = 380$ . |                                                                                                                                                                        |                                                                                                                                                                         |
| ★ 8  | Determines and announces replot (true) range.<br>Range corresponding to elevation $380 = 5590$ .<br>Announces: REPLOT<br>DEFLECTION ..... 3208<br>RANGE ..... 5590   | Polar plots final replot range and deflection; measures and announces replot grid: REPLOT<br>GRID 43733416.<br>Tick marks in red and labels the final target location. | Announces: REPLOT<br>ALTITUDE ..... 373.                                                                                                                                |
| 9    | Records replot grid and altitude on record of fire.                                                                                                                  |                                                                                                                                                                        |                                                                                                                                                                         |

#### 10-4. Replot with VT Fuze (M513/M514)

**Example:**

Given: GFT setting given in paragraph 10-3. Completed Record of Fire (fig 10-4).

**Solution:**

| STEP | COMPUTER |
|------|----------|
|------|----------|

- |   |                                                                                                                                                                            |              |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1 | Determines final ground QE and first apparent elevation.                                                                                                                   |              |
|   | Final QE                                                                                                                                                                   | 374          |
|   | -20/R                                                                                                                                                                      | -(+4)        |
|   | Ground QE                                                                                                                                                                  | <u>370</u>   |
|   | -Site fired                                                                                                                                                                | <u>-(11)</u> |
|   | First apparent elevation                                                                                                                                                   | 381          |
| 2 | Supervises FDC team in successively approximating the true target location until site agrees within $\pm 1$ mil in accordance with the procedures shown in paragraph 10-3. |              |

[illegible]

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Figure 10-4. Completed Record of Fire—VT fuze.

### 10-5. Replot with Time Fuze

a. When a target is attacked with time fuze, the HOB is adjusted by the observer to 20 meters above the target. The final fuze setting that corresponds to the 20-meter HOB provides an accurate representation of the target location and the altitude of a point 20 meters above the target (fig 10-5). Consequently, when the time gageline is placed over the final time, the range and 100/R read under the MHL and the elevation and drift correction read under the elevation gageline are true. The replot grid and altitude can then be determined.

b. The replot procedures begin as follows:

(1) Place the time gageline over the final time.

(2) Under the MHL, read replot range and 100/R.

(3) Under the elevation gageline, read true elevation and drift.

c. The replot deflection is determined by adding the drift determined in (3) above to the GFT deflection correction to determine the true total deflection correction. This true total

deflection correction is then subtracted from the final piece deflection.

d. The replot grid and altitude are determined as follows:

(1) The computer determines replot range and deflection as in *b* and *c* above and announces them to the HCO.

(2) The HCO polar plots the target using the replot range and deflection and determines the replot grid.

(3) The computer subtracts the true elevation from the final quadrant and obtains true total site.

(4) The computer determines the value of 20/R and subtracts the 20/R value from the total site fired to obtain true ground site.

(5) Using the GST, the VCO determines the VI by multiplying the true ground site by the replot range. He then algebraically adds the VI to the battery altitude and announces the sum to the computer as the target altitude.

#### Example:

Given: GFT setting given in example in paragraph 10-3. Completed Record of Fire (fig 10-6).

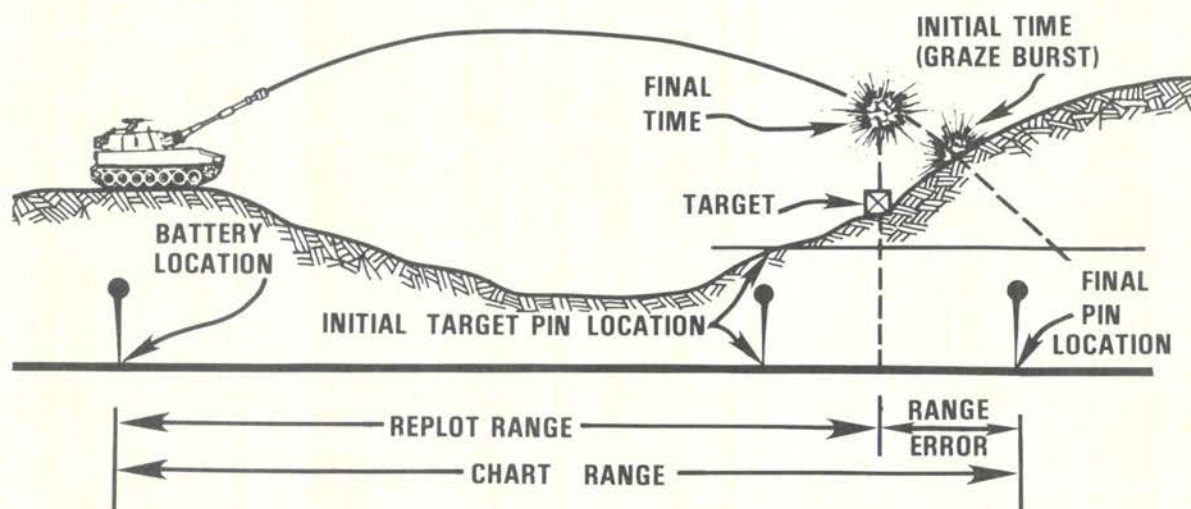


Figure 10-5. Time replot.

## RECORD OF FIRE

|                        |          |                   |             |                          |         |                       |          |                |          |          |          |    |     |       |     |      |
|------------------------|----------|-------------------|-------------|--------------------------|---------|-----------------------|----------|----------------|----------|----------|----------|----|-----|-------|-----|------|
| Observer <b>B21</b>    |          | CALL FOR FIRE     |             | ALT REG PT 2 355 GFT R2  |         | △ FS .12              |          |                |          |          |          |    |     |       |     |      |
| Grid: _____            |          | AP/FE/IS/S _____  |             | Tgt _____                |         | ALT BTRY 405 DFT L6   |          |                |          |          |          |    |     |       |     |      |
| Polar: Dir _____       |          | Dis _____         |             | U/D _____                |         | VI-50                 |          |                |          |          |          |    |     |       |     |      |
| Shift: REG PT 2        |          | Dir 600           |             | Q 300                    |         | +0 400 U/D _____      |          |                |          |          |          |    |     |       |     |      |
| BRDM w/ DISMOUNTED INF |          | Si ÷ 10           |             | 10m Si                   |         | MOB Corr              |          |                |          |          |          |    |     |       |     |      |
| FIRE ORDER ② TI 'E     |          | Df Corr L4        |             | Si -12                   |         |                       |          |                |          |          |          |    |     |       |     |      |
| INITIAL FIRE COMMANDS  |          | MF BTRY ADJ       |             | Rg 4700                  |         | Chf Df 3210           |          |                |          |          |          |    |     |       |     |      |
| Sp Instr               |          | Sh                |             | Lot                      |         | Chg 4 Fz Ti           |          |                |          |          |          |    |     |       |     |      |
| MTO H47, ②, FZ TI      |          | T                 |             | PER                      |         | TF                    |          |                |          |          |          |    |     |       |     |      |
|                        |          |                   |             |                          |         | ② TI in Eff           |          |                |          |          |          |    |     |       |     |      |
|                        |          |                   |             |                          |         | Ammo Exp ①            |          |                |          |          |          |    |     |       |     |      |
| Tgt                    | Location | Priority          | Firing Unit | SUBSEQUENT FIRE COMMANDS |         |                       |          |                |          |          |          |    |     |       |     |      |
| Dir, MF Sh, Fz         | Dev      | Rg                | HOB Corr    | MF, Sh, Chg, Fz          | FS Corr | Ti                    | Chart Df | Df Corr (L4)   | Df Fired | Chart Rg | HOB Corr | Si | El  | QE    | Exp | Type |
| FZ TI                  | -100     |                   | FZ TI       |                          |         | 16.9                  | 3210     | L4             | 3214     | 4600     | +4       | -8 | 294 | 286   | ①   |      |
|                        |          |                   | U5          | BTRY ②                   | -0.1    | 16.8                  |          |                | 3214     |          |          |    |     | 286   | ⑬   | TI ✓ |
|                        |          |                   | U5          | EM                       |         | (16.8)                |          |                | 3214     |          | +1       | -7 | 294 | (287) |     |      |
| REC AS TGT, EM         |          |                   |             |                          |         |                       |          |                |          |          |          |    |     |       |     |      |
| 5/R=4                  |          |                   |             |                          |         |                       |          |                |          |          |          |    |     |       |     |      |
| Btry B                 |          | DTG 141430 JUL 80 |             | Tgt AG 6472              |         | Replot Grid 4591 2611 |          | Replot Alt 359 |          |          |          |    |     |       |     |      |

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Figure 10-6. Completed Record of Fire—time fuze.

## Solution:

| STEP | COMPUTER                                                                                                                                                        | HCO | VCO |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|
| 1    | Places the time gageline over the final time (16.8) and determines: Replot range (MHL) 4590<br>100/R (MHL) 22<br>True elevation (EL GL) 292<br>Drift (EL GL) L6 |     |     |
| 2    | Determines replot deflection:<br>Drift correction L6<br>GFT deflection correction R2<br>True total df corr L4                                                   |     |     |

Final piece  
deflection 3214  
Replot deflection 3210

★ 3 Announces: REPLOT  
DEFLECTION 3210  
RANGE 4590 Polar plots data  
and announces:  
REPLOT GRID  
45912611.

★ 4 Determines true ground  
site.

|                  |       |
|------------------|-------|
| Final QE         | 287   |
| -True elevation  | -294  |
| True total site  | -7    |
| -20/R            | -(+4) |
| True ground site | -11   |

Announces:  
SITE BRAVO -11.

Determines target  
altitude.

|                    |        |
|--------------------|--------|
| True ground site   | -11    |
| × Range (GST)      | × 4590 |
| VI                 | -46    |
| + Battery altitude | 405    |
| Target altitude    | 359    |

Announces:  
REPLOT ALTITUDE 359.

5 Records replot grid and  
altitude on Record of Fire.

## Section II. FADAC PROCEDURES

### 10-6. Replotting Targets with FADAC

FADAC provides the quickest means for replotting targets. FADAC determines the replot location by recomputing the ballistic trajectory and displaying the grid and altitude of the point of impact. The following replot procedures are the same for all fuzes:

a. The HCO applies the FO's refinement data to the fire for effect data.

b. The VCO plots the FADAC target

location on a map and determines the altitude.

(1) If the map altitude is within one-half contour interval of the FADAC altitude, the FADAC coordinates and altitude are considered the replot location.

(2) If the FADAC and map altitude are not within one-half a contour interval, successive approximation must be performed. This is accomplished by entering

## **C1, FM 6-40**

the map altitude into FADAC and recomputing a new replot location and altitude. Successive approximation is continued until the replot altitude criteria are met.

### **10-7. FADAC Reference**

For detailed procedures for determining FADAC replot data, consult the FADAC User's Manual.



## ★ CHAPTER 11

# FIRE DIRECTION PROCEDURES FOR SPECIAL MUNITIONS

### Section I. ICM/FASCAM

#### 11-1. Characteristics and Employment

a. Characteristics and employment of improved conventional munitions (ICM) are discussed in FM 6-30. As with ICM, the family of scatterable munitions are base ejection type projectiles, are fired with a mechanical time fuze (M577 or M724), and are filled with a number of submunitions. These submunitions—mines—are ejected through the base of the projectile and then scattered randomly about the target area. Table 11-1

shows the number of mines contained in the FASCAM rounds.

b. FASCAM projectiles are of two types, the area denial artillery munitions (ADAM) projectile and the remotely activated antitank mines (RAAM) projectile.

(1) The FASCAM ADAM projectile is used to deny the enemy use of certain areas. Each mine arms itself after it comes to rest on the ground. Individual trip wires are extended from each mine, which will activate

Table 11-1. FASCAM Projectiles

#### FASCAM PROJECTILES

| AREA DENIAL ARTILLERY MUNITIONS (ADAM)         |            |                 |
|------------------------------------------------|------------|-----------------|
| WEAPON                                         | PROJECTILE | NUMBER OF MINES |
| 155-mm                                         | M692/M731  | 36              |
| REMOTELY ACTIVATED ANTITANK MINE SYSTEM (RAAM) |            |                 |
| 155-mm                                         | M718/M741  | 9               |

the explosive when disturbed by enemy movement.

(2) The FASCAM RAAM projectile is most effective against armored vehicles. These mines become armed within a few seconds after landing. Any metallic object, such as a tank, self-propelled vehicle, or other type unit, passing over the mines will cause them to activate and damage or destroy the equipment. If after a certain period of time the mines have not been activated, they also provide a mechanism for self-destruction. Scattered among the mines are some that have an antidisturbance firing mechanism that can cause casualties if disturbed by enemy personnel attempting to clear the mined area.

## 11-2. Manual Solution Using GFT

*a. Explanation of GFT Scales.* The base scale of the 155-AN-1 M483A1 GFT is for the M483A1 DPICM projectile in the self-registration mode. This base scale is used to determine initial firing data for the field artillery delivered munitions DPICM, ADAM, or RAAM. The DPICM scale is located above the base scale and consists of the QE and fuze setting (fig 11-1). These values contain the ballistic and height of burst corrections from tables A and B of the appropriate addendum to the TFT.

*b. Determination of Firing Data.* Using the announced chart range and site, the fuze

setting and quadrant elevation for a 0-meter height of burst are determined from the base scale. ICM data is then determined as follows:

(1) *Fuze setting.* The DPICM projectiles are fuzed with the M577 mechanical time fuzes. The fuze setting is determined by placing the manufacturer's hairline on the cursor over the M577 fuze setting and reading the M577 fuze setting under the MHL on the fuze setting portion of the DPICM scale.

(2) *Deflection.* The piece deflection determined for DPICM is the same as that determined for the base scale round.

(3) *Quadrant elevation.* QE for shell DPICM is determined by first computing the base scale QE. The MHL is placed over the base scale QE on the elevation scale and the quadrant elevation for DPICM is read directly from the prepared DPICM quadrant elevation scale underneath the MHL.

*c. Subsequent Corrections.* When the observer sends range and/or deviation corrections, firing data is determined by first plotting the correction on the chart, then determining a new chart range and chart deflection. DPICM firing data is then determined as discussed above. When the observer includes an HOB correction, the DPICM quadrant and fuze setting to fire, as determined above, must be corrected by using corrections extracted from the addendum to the tabular firing tables as follows:

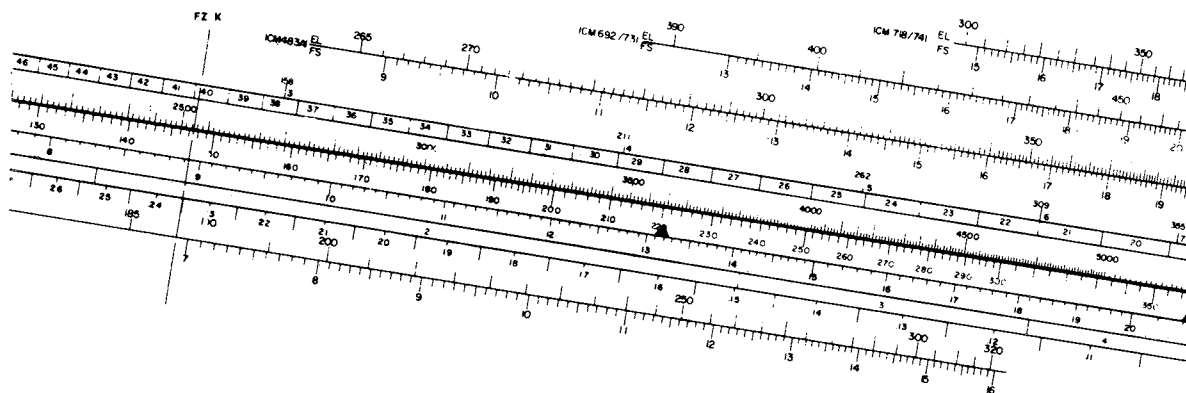


Figure 11-1. M483A1 GFT scale.

(1) *Fuze setting (table B appropriate charge) (fig 11-2).*

(a) Enter column 1 with the fuze setting from the base scale.

(b) From the column headed "Correction to Fuze Setting for an Increase of 50 Meters in Height," extract a correction factor for a 50-meter increase in HOB.

(c) Multiply the correction factor by the number of 50-meter increments needed.

(d) Apply the fuze correction to the uncorrected ICM fuze setting.

(2) *Quadrant elevation (table A appropriate charge) (fig 11-3).*

(a) Enter column 1 with the HE QE determined from the chart data. (Enter to the nearest listed value.)

(b) From the column headed "Correction to Quadrant Elevation for an Increase of

CHARGE  
40

TABLE B  
FUZE SETTING

FT 155 ADD-J-1  
PROJ. HE, M483A1  
FUZE, MTSQ, M577

| 1<br>FUZE SETTING<br>FOR<br>PROJ. M483A1 | 2<br>CORRECTION TO<br>FUZE SETTING<br>FOR<br>PROJ. M483A1 | 3<br>CORRECTIONS TO FUZE SETTING<br>FOR AN INCREASE OF<br>50 METERS<br>IN HEIGHT | 4<br>CORRECTIONS TO FUZE SETTING<br>FOR AN INCREASE OF<br>100 METERS<br>IN RANGE |
|------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 10.0-15.1                                | -1.3                                                      | 0.0                                                                              | 0.4                                                                              |
| 15.2-20.9                                | -1.2                                                      | 0.1                                                                              | 0.5                                                                              |
| 21.0-25.1                                | -1.1                                                      | 0.1                                                                              | 0.6                                                                              |
| 25.2-28.2                                | -1.0                                                      | 0.2                                                                              | 0.7                                                                              |
| 28.3-30.5                                | -0.9                                                      | 0.2                                                                              | 0.8                                                                              |
| 30.6-32.2                                | -0.8                                                      | 0.3                                                                              | 1.0                                                                              |
| 32.3-33.4                                | -0.7                                                      | 0.3                                                                              | 1.2                                                                              |
| 33.5-34.1                                | -0.6                                                      | 0.4                                                                              | 1.4                                                                              |
| 34.4-35.0                                | -0.5                                                      | 0.5                                                                              | 1.6                                                                              |
| 35.1-35.6                                | -0.4                                                      | 0.6                                                                              | 2.0                                                                              |
| 35.7-36.0                                | -0.3                                                      | 0.8                                                                              |                                                                                  |
| 36.1-36.4                                | -0.2                                                      | 0.9                                                                              |                                                                                  |
| 36.5-36.6                                | -0.1                                                      | 1.1                                                                              |                                                                                  |
| 36.7-36.9                                | 0.0                                                       |                                                                                  |                                                                                  |
| 37.0-37.1                                | 0.1                                                       |                                                                                  |                                                                                  |
| 37.2                                     | 0.2                                                       |                                                                                  |                                                                                  |
| 37.3                                     | 0.3                                                       |                                                                                  |                                                                                  |
| 37.4                                     | 0.4                                                       |                                                                                  |                                                                                  |
| 37.5                                     | 0.5                                                       |                                                                                  |                                                                                  |
| 37.6                                     | 0.6                                                       |                                                                                  |                                                                                  |
| 37.7                                     | 0.7                                                       |                                                                                  |                                                                                  |
| 37.8                                     | 0.9                                                       |                                                                                  |                                                                                  |
| 43.5                                     | -3.3                                                      |                                                                                  |                                                                                  |
| 43.6                                     | -3.1                                                      |                                                                                  |                                                                                  |
| 43.7                                     | -2.9                                                      |                                                                                  |                                                                                  |
| 43.8                                     | -2.8                                                      |                                                                                  |                                                                                  |
| 43.9                                     | -2.7                                                      |                                                                                  |                                                                                  |
| 44.0                                     | -2.6                                                      |                                                                                  |                                                                                  |
| 44.1                                     | -2.5                                                      |                                                                                  |                                                                                  |
| 44.2-44.3                                | -2.4                                                      |                                                                                  |                                                                                  |
| 44.4-44.5                                | -2.3                                                      | -1.4                                                                             |                                                                                  |
| 44.6-44.7                                | -2.2                                                      | -1.2                                                                             |                                                                                  |
| 44.8-45.0                                | -2.1                                                      | -1.0                                                                             |                                                                                  |
| 45.1-45.4                                | -2.0                                                      | -0.9                                                                             | -2.1                                                                             |

Figure 11-2. Table B, ICM addendum.

FT 155 ADD-J-1

TABLE A

CHARGE  
40

PROJ. HE, M483A1  
FUZE, MTSQ, M577

QUADRANT ELEVATION

| 1<br>QUADRANT<br>ELEVATION<br>FOR PROJ.<br>M483A1 | 2<br>CORRECTION<br>TO QUADRANT<br>ELEVATION<br>FOR PROJ.<br>M483A1 | 3<br>CORRECTIONS TO<br>QUAD ELEV<br>FOR AN<br>INC OF<br>50 M<br>IN HGT | 4<br>CORR<br>FOR LOW<br>LEVEL<br>WIND OF<br>1 KNOT | 5<br>TIME<br>OF<br>FLIGHT | 6<br>RANGE<br>TO<br>IMPACT |
|---------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------|---------------------------|----------------------------|
| MILS                                              | MILS                                                               | MILS                                                                   | MILS                                               | SEC                       | METERS                     |
| 150                                               | 39                                                                 | 11.8                                                                   | 8.2                                                | 3.7                       | 5599                       |
| 155                                               | 38                                                                 | 11.7                                                                   | 8.3                                                | 3.6                       | 5641                       |
| 160                                               | 37                                                                 | 11.6                                                                   | 8.4                                                | 3.6                       | 5684                       |
| 165                                               | 37                                                                 | 11.6                                                                   | 8.6                                                | 3.6                       | 5726                       |
| 170                                               | 36                                                                 | 11.5                                                                   | 8.7                                                | 3.5                       | 5768                       |
| 375                                               | 36                                                                 | 11.4                                                                   | 8.9                                                | 3.5                       | 5810                       |
| 380                                               | 35                                                                 | 11.4                                                                   | 9.0                                                | 3.5                       | 5852                       |
| 385                                               | 35                                                                 | 11.3                                                                   | 9.2                                                | 3.4                       | 5893                       |
| 390                                               | 34                                                                 | 11.3                                                                   | 9.3                                                | 3.4                       | 5934                       |
| 395                                               | 34                                                                 | 11.3                                                                   | 9.5                                                | 3.4                       | 5975                       |
| 400                                               | 33                                                                 | 11.2                                                                   | 9.7                                                | 3.3                       | 6015                       |
| 405                                               | 33                                                                 | 11.2                                                                   | 9.8                                                | 3.3                       | 6055                       |
| 410                                               | 32                                                                 | 11.2                                                                   | 10.0                                               | 3.3                       | 6095                       |
| 415                                               | 32                                                                 | 11.1                                                                   | 10.2                                               | 3.3                       | 6134                       |
| 420                                               | 32                                                                 | 11.1                                                                   | 10.3                                               | 3.2                       | 6172                       |
| 425                                               | 31                                                                 | 11.1                                                                   | 10.5                                               | 3.2                       | 6211                       |
| 430                                               | 31                                                                 | 11.1                                                                   | 10.7                                               | 3.2                       | 6249                       |
| 435                                               | 30                                                                 | 11.1                                                                   | 10.9                                               | 3.1                       | 6286                       |
| 440                                               | 30                                                                 | 11.1                                                                   | 11.1                                               | 3.1                       | 6323                       |
| 445                                               | 30                                                                 | 11.1                                                                   | 11.3                                               | 3.1                       | 6360                       |
| 450                                               | 30                                                                 | 11.1                                                                   | 11.5                                               | 3.1                       | 6396                       |
| 455                                               | 29                                                                 | 11.1                                                                   | 11.7                                               | 3.0                       | 6432                       |
| 460                                               | 29                                                                 | 11.1                                                                   | 11.7                                               | 3.0                       | 6468                       |
| 465                                               | 29                                                                 | 11.2                                                                   | 12.1                                               | 3.0                       | 6502                       |
| 470                                               | 29                                                                 | 11.2                                                                   | 12.4                                               | 2.9                       | 6537                       |
| 475                                               | 28                                                                 | 11.2                                                                   | 12.6                                               | 2.9                       | 6571                       |
| 480                                               | 28                                                                 | 11.3                                                                   | 12.9                                               | 2.9                       | 6604                       |
| 485                                               | 28                                                                 | 11.3                                                                   | 13.1                                               | 2.9                       | 6637                       |
| 490                                               | 28                                                                 | 11.3                                                                   | 13.4                                               | 2.8                       | 6670                       |
| 495                                               | 27                                                                 | 11.4                                                                   | 13.7                                               | 2.8                       | 6702                       |
| 500                                               | 27                                                                 | 11.5                                                                   | 14.0                                               | 2.8                       | 6733                       |
| 505                                               | 27                                                                 | 11.5                                                                   | 14.3                                               | 2.8                       | 6764                       |
| 510                                               | 27                                                                 | 11.6                                                                   | 14.6                                               | 2.7                       | 6795                       |
| 515                                               | 27                                                                 | 11.7                                                                   | 14.9                                               | 2.7                       | 6825                       |
| 520                                               | 27                                                                 | 11.8                                                                   | 15.3                                               | 2.7                       | 6854                       |
| 525                                               | 27                                                                 | 11.9                                                                   | 15.6                                               | 2.7                       | 6883                       |

Figure 11-3. Table A, ICM addendum.

50 Meters in Height," determine the correction factor for an increase of 50 meters HOB.

(c) Multiply the correction factor by the number of 50-meter increments needed and express the product to the nearest 1 mil.

(d) Apply the HOB correction to the uncorrected ICM quadrant.

### 11-3. ADAM/RAAM Projectiles

a. The fire direction technique for delivering field artillery scatterable mines depends on the type of minefield being emplaced. These minefields can be either planned or target of opportunity minefields. In either case, the initial firing data is based on the registration corrections determined from the M483A1 (DPICM) registration.

Table 11-2. Minefield Modules

| PROJECTILES      | LOW ANGLE FIRE   | HIGH ANGLE FIRE  |
|------------------|------------------|------------------|
| M718/M741 (RAAM) | 200 × 200 meters | 400 × 400 meters |
| M692/M731 (ADAM) | 400 × 400 meters | 400 × 400 meters |

Techniques for determining firing data for the M692/M731 (ADAM) or M718/M741 (RAAM) are:

(1) *Planned.*

(a) Transfer technique is preferred when the minefield falls within the transfer limits of the registration.

(b) Met + VE technique is used when the minefield location falls outside the transfer limits.

(c) Met to target technique is used when a registration is not feasible and position constants are not available. In this case, the FDC applies a position deflection correction of zero, a position VE determined for the charge by a velocimeter, and a position fuze correction in the form of a known fuze correction.

(2) *Target of opportunity.* The observer adjustment technique is used when target of opportunity minefields are requested.

b. Firing data for the ADAM and RAAM can be determined by applying ballistic corrections to the M483A1 registration data. Ballistic corrections compensate for the weight, center of gravity, and height of burst differences between projectiles.

#### 11-4. Battery-Minefield Angle

The battery-minefield angle (BMA) is the smaller angle formed by the intersection of the minefield center line with a line drawn from the battery center to the center point of the minefield. The BMA is one of the entry arguments to the aimpoint tables in the TFT.

#### 11-5. Determination of Firing Data by the Manual Method

Upon receipt of an artillery delivered minefield mission, the FDC will:

a. Select the appropriate technique to determine firing data (para 11-3).

b. Determine from the appropriate TFT the number of aimpoints required to emplace a minefield module. Arguments for entry to tables are the basis for corrections to be used. These arguments are the BMA, trajectory, range expressed to the nearest 2000 meters, and desired minefield size (table 11-2).

*Note.* The aimpoint tables for met + VE are used for both the transfer and met + VE techniques.

c. Determine the location of the aimpoints.

(1) *Module size 400 × 400 meters, odd number of aimpoints.* Place the first aimpoint at the center point of the minefield. Place the others at intervals of 400 meters left and right of the center point, along the center line (fig 11-4).

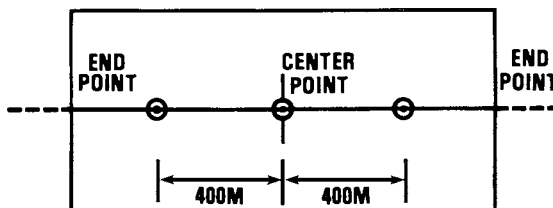


Figure 11-4. Module size 400 × 400 meters, odd number of aimpoints.

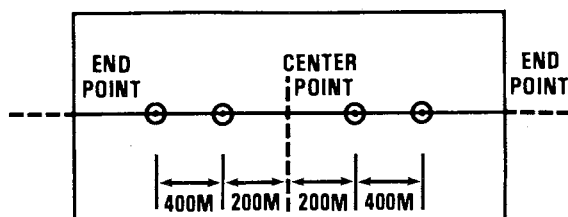


Figure 11-5. Module size 400 × 400 meters, even number of aimpoints.

(2) *Module size 400 × 400 meters, even number of aimpoints.* Place aimpoints 200 meters left and right of the center point along the center line. Place the others at intervals of 400 meters (fig 11-5).

(3) *Module size 200 × 200 meters, odd number of aimpoints.* Place the first aimpoint at the center point of the minefield. Place the others at intervals of 200 meters left and right of the center point along the center line.

(4) *Module size 200 × 200 meters, even number of aimpoints.* Place aimpoints 100 meters left and right of the center point along the center line. Place the others at intervals of 200 meters.

d. Determine the number of projectiles per aimpoint. The number of projectiles required to achieve the desired density within each module (as defined by each aimpoint) is determined by entering tables 11-3 through 11-5, as appropriate. Entry arguments to the tables are projectile type, trajectory, and desired density from the artillery delivered minefield planning sheet.

Table 11-3. M718/M741 (RAAM) High Angle Fire

|                     | LOW  | MED  | HIGH |
|---------------------|------|------|------|
| Desired Density     | .001 | .002 | .004 |
| Rounds Per Aimpoint | 24   | 48   | 96   |

Table 11-4. M718/M741 (RAAM) Low Angle Fire

|                     | LOW  | MED  | HIGH |
|---------------------|------|------|------|
| Desired Density     | .001 | .002 | .004 |
| Rounds Per Aimpoint | 6    | 12   | 24   |

Table 11-5. M692/M731 (ADAM) High or Low Angle

|                     | LOW   | MED  | HIGH |
|---------------------|-------|------|------|
| Desired Density     | .0005 | .001 | .002 |
| Rounds Per Aimpoint | 3     | 6    | 12   |

e. Determine firing data for RAAM and ADAM. The basis for corrections for artillery scatterable mines is that data to fire shell M483A1 in the self-registration (SR) mode. Ballistic corrections are applied for each of the scatterable mine projectiles. The corrections are obtained from the appropriate firing table addendum (for low and high angle fire) or are graphically portrayed on GFT 155-AN-1 M483A1 (low angle only).

(1) *RAAM.*

(a) Using either the transfer or the met + VE technique, determine a deflection, quadrant elevation, and fuze setting to fire shell M483A1 in the SR mode.

(b) Enter table A, FT 155 ADD-N-1, for the appropriate charge. From column 2 extract a ballistic correction to quadrant elevation for shell M718/M741. Apply this ballistic correction to the quadrant elevation for shell M483A1 to determine the quadrant to fire shell M718/M741. For the transfer technique, use the GFT 155-AN-1 M483A1. Place the MHL over the quadrant elevation for shell M483A1 in the SR mode, and under the MHL read a quadrant elevation for shell M718/M741.

(c) Enter table B, FT 155 ADD-N-1, for the appropriate charge. From column 2

extract a ballistic correction to fuze setting for shell M718/M741. Apply this correction to the M577 fuze setting determined for shell M483A1 to determine the fuze setting to fire shell M718/M741. Alternatively, using GFT 155-AN-1 M483A1, place the MHL over the fuze setting for shell M483A1 in the SR mode, and, under the MHL, read a fuze setting for shell M718/M741.

*Note.* Corrections for low level winds are not used when firing shell M718/M741.

## (2) ADAM.

(a) Using either the transfer or met + VE technique, determine a quadrant elevation to fire shell M483A1 in the SR mode.

(b) Enter table A, FT 155 ADD-L-1, for the appropriate charge. From column 5 extract the correction for a low level wind of 1 knot.

(c) Take the wind speed and direction from line 02 of the most current met. Multiply the wind speed by the wind correction factor to determine the wind displacement distance. The distance is expressed to the nearest 10 meters. For example, the wind speed from line 02 is 24 knots and the correction factor is 9.0. The wind displacement distance is 220 meters ( $24 \text{ knots} \times 9.0 \text{ meters/knot} = 216 \text{ meters} \sim 220 \text{ meters}$ ).

(d) Using the target grid centered over the initial aimpoint, turn off the wind direction from line 02 and move the pin 220 meters up the arrow on the target grid. This places the new aimpoint 200 meters into the wind.

(e) Determine new M483A1 SR data and FASCAM data for the new aimpoint in one of the following ways:

### 1. Transfer technique.

- Place the MHL over the range to the new aimpoint location. Determine a total deflection correction, and apply this to the deflection determined to the new aimpoint location.

- Using GFT 155-AN-1 M483A1, place the MHL over the quadrant elevation for shell M483A1 in the SR mode, and, under

the MHL, read a quadrant elevation for shell M692/M731.

- Determine a fuze setting for shell M483A1. Using GFT 155-AN-1 M483A1, place the MHL over the fuze setting for shell M483A1 in the SR mode, and, under the MHL, read a fuze setting for shell M692/M731.

### 2. Met + VE technique.

- Apply the total deflection correction determined on the met data correction sheet to the deflection determined to the displaced pin location.

- Apply the total range correction determined on the met data correction sheet to the range determined to the displaced pin location. Determine a quadrant elevation for shell M483A1 in the SR mode. Using FT 155 ADD-L-1, enter table A for the appropriate charge. From column 2 extract a ballistic correction to quadrant elevation for shell M692/M731. Apply this ballistic correction to the quadrant elevation for shell M483A1 to determine the quadrant to fire shell M692/M731. Alternatively, using GFT 155-AN-1 M483A1, place the MHL over the quadrant elevation for shell M483A1 in the SR mode, and, under the MHL, read a quadrant elevation for shell M692/M731.

- Determine a fuze setting for shell M483A1 in the SR mode. Apply the total fuze correction from the met data correction sheet to the fuze setting to fire shell M483A1 in the SR mode. Using FT 155 ADD-L-1, enter table B for the appropriate charge. From column 2 extract a ballistic correction to fuze setting for shell M692/M731. Apply this correction to the M577 fuze setting for shell M483A1 to determine the fuze setting to fire shell M692/M731. Alternatively, using GFT 155-AN-1 M483A1, place the MHL over the fuze setting for shell M483A1 in the SR mode, and, under the MHL, read a fuze setting for shell M692/M731. If an observer is to verify the location of the minefield, the following procedures will be followed:

- An adjustment is first made with shell M483A1 in the SR mode.

- The total correction provided by the observer is applied to each aimpoint

along with the appropriate correction for low level wind, if required. Remember that each aimpoint must be displaced by the amount of the low level wind correction before firing data for shell M692/M731 is determined.

#### 11-6. Determination of Firing Data With FADAC

When FADAC is being used as the primary source for determining firing data, the basis for corrections will be data to fire shell M483A1 in the SR mode.

*a. Transfer.* The appropriate charge, fuze, and shell (M483A1) are overridden in row B, and the residuals determined for shell M483A1 are applied in row F (DF CORR, TIME CORR, RG K). A deflection, time, and quadrant elevation are then determined for shell M483A1. Using either a GFT or a TFT, ballistic corrections are then determined and applied to fire shell M718/M741 or shell M692/M731.

*b. Met + VE Technique.* The appropriate charge, fuze, and shell (M483A1) are overridden in row B. The deflection residual is carried forward and overridden in row F (DF CORR). The current met will be in the FADAC. The MV for shell M483A1 will be entered in row G. A deflection, time, and quadrant elevation are then determined for shell M483A1. Using either a GFT or a TFT, ballistic corrections are then determined and applied to fire shell M718/M741 or shell M692/M731.

*c. Observer Adjust Technique.* Adjust and fire for effect data are determined with shell M483A1. Using a GFT or a TFT, ballistic corrections are then determined and applied to fire shell M718/M741 or shell M692/M731.

(1) Computational procedures in the form of sample problems are in the introduction to FT 155 ADD-L-1.

(2) Uniform scattering of mines and consistent module size are attained by:

(a) Applying special corrections to the pieces firing the mission to obtain a converged sheaf when only one aimpoint is being engaged.

(b) Applying special corrections, assigning each piece to an individual aimpoint when multiple aimpoints are being engaged.

(c) When more than one aimpoint is required, attempting to fire at all aimpoints simultaneously.

(d) If the number of aimpoints exceeds the number of howitzers available, firing the central aimpoints first.

(e) When RAAM and ADAM are being delivered together, firing the RAAM first, followed by the ADAM.

(3) Generally, a long self-destruct time is used in emplacing a planned minefield. However, in all cases, the self-destruct times are determined in the planning process and provided to the FDC.

(4) Variations from the standard fire order/fire commands are announced as appropriate.

#### 11-7. ICM/DPICM Fire Order/Fire Commands

*a. Fire order/fire commands for ICM/scatterable mine projectiles* are similar to those for other types of projectiles except for the different types of scatterable mines and modes of the DPICM projectile. To avoid differences between the FDC and the gun sections, the following are commands for projectile identification:

(1) For M444/M449 series and M404 ICM projectiles, the command is **SHELL ICM, LOT—**.

(2) For the M483A1 or M509E1 DPICM projectile, the difference in mode must be identified. For the self-registration mode, the command is **SHELL DP-SR** (dual purpose—self-registration). If the projectile is to be fired in effect (FFE), the command is **SHELL DP**.

(3) The ADAM and RAAM can be fired only after a registration with the DPICM-SR mode (M483A1 projectile). For short destruct rounds, the command is **SHELL RAAM-S**.

For long destruct rounds, the command is **SHELL ADAM-L**. The ADAM and RAAM have two self-destruct times for each type of projectile.

b. To help reduce confusion between the FDC and the gun section, each projectile lot number must be assigned a different lot code letter. The only exception would be for the DPICM projectile.

#### 11-8. Minefields Delivered Against Targets of Opportunity

a. *FO Procedures.* Upon detection of a suitable target of opportunity for suppression/neutralization with artillery delivered minefields, the observer will determine:

(1) *The location of the aimpoint.*

(a) *Moving targets.* The aimpoint is placed directly on the enemy axis of advance 1000 meters in front of the enemy for every 10 km/hr of enemy speed. This allows sufficient time for mine delivery and arming before enemy encounter yet does not allow the enemy time to redeploy (fig 11-6).

(b) *Stationary targets.* The aimpoint is placed directly over the target center. The observer locates the aimpoint to an accuracy of 100 meters (six-digit coordinates).

(2) *The call for fire.* The fire mission request is transmitted and processed the same as for other fire missions. The request must specify:

(a) Identification (call sign).

(b) Warning order (include RAAM, ADAM, or both).

(c) Target location (six-digit coordinates).

(d) Target description.

(e) Method of engagement.

1. The type of projectile is determined by the observer/requester and is based on the nature of the target. The RAAM should be

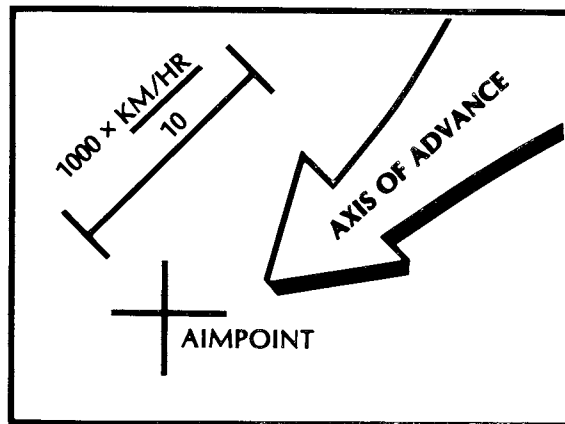


Figure 11-6. Location of the aimpoint.

used to attack an armored unit. The ADAM should be used to attack a counterfire target. If the unit is self-propelled, a mix of ADAM and RAAM should be used.

2. Self-destruct time is mentioned in the call for fire only if the long self-destruct time is desired (fig 11-7). Short is understood if self-destruct time is not mentioned (fig 11-8).

(f) Method of fire and control.

1. The standard volume of fire to be delivered is in table 11-6. The total number of rounds may be increased if a higher density minefield is desired and ammunition is available.

2. The M483A1 projectile in the self-registration mode will be the adjusting round for an adjust fire mission.

A4257 THIS IS A4242, FIRE FOR  
EFFECT, ADAM-L, OVER.  
GRID 180513, OVER.  
ENEMY MORTAR POSITION,  
OVER.

Figure 11-7. Sample call for fire,  
fire for effect mission, long time.

A4257 THIS IS A4722, ADJUST  
FIRE, RAAM, OVER.  
GRID 133216, OVER.  
FIVE T-72 TANKS ATTACKING,  
OVER.

Figure 11-8. Sample call for fire,  
adjust fire mission, short time.



Table 11-6. Planned Minefield Volume of Fire

|                                                                            | ADAM<br>(LA and HA) | RAAM<br>(LA) | RAAM<br>(HA) |
|----------------------------------------------------------------------------|---------------------|--------------|--------------|
| <b>No. of Rounds Required</b>                                              | 6                   | 12           | 24           |
| <b>Probability of No Encounter<br/>(Single Vehicle/Man)</b>                | .12                 | .27          | .27          |
| <b>Probability of at Least One<br/>Encounter (Single Vehicle/<br/>Man)</b> | .88                 | .73          | .73          |

*b. FDC Procedures.* Upon receipt of a call for fire for an artillery delivered minefield, the FDC will:

(1) Conduct the adjustment phase of the mission (if required) with shell M483A1 in the self-registration mode.

(2) Determine the number of rounds to be fired in effect (table 11-6).

*Note.* The rounds required as determined from table 11-6 represent total expenditures per mission, not rounds per howitzer.

(3) Using either the appropriate firing table addendum or GFT 155-AM-1 M483A1, apply the necessary ballistic corrections to the fire for effect data determined for shell M483A1 to determine data for shell M718/M741 or M692/M731.

(4) Determine and announce variations from the standard fire order/fire commands, as appropriate.

(5) Determine and apply terrain gun position corrections for the fire for effect phase.

(6) Generally, use a short self-destruct time in emplacing a minefield against targets of opportunity.

(7) Complete DA Form 4504, Record of Fire, as indicated in figures 11-9 and 11-10.

(8) Complete and forward to the brigade fire support officer, Section IV, FDC Data, of

| RECORD OF FIRE                                                                          |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
|-----------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------|--|-----------|--|------------------|
| Observer: CALL FOR FIRE AF/FFE/IS/S                                                     |  |  |  |  |  |  |  |  |  | Tgt                           |  | TGT: 381  |  | △ FS             |
| Grid: <b>AIMPOINT: 6438 3670</b>                                                        |  |  |  |  |  |  |  |  |  | FROM MINEFIELD PLANNING SHEET |  | BTRY: 355 |  | 100/R            |
| Polar: Dir _____ Dis _____ U/D _____                                                    |  |  |  |  |  |  |  |  |  | VI: +26                       |  | GFT: R2   |  | /R               |
| Shift: <b>ADAM - LONG DESTRUCT, (6), ON CALL</b>                                        |  |  |  |  |  |  |  |  |  | U/D                           |  | DRIFT: L7 |  | 20/R             |
| FIRE ORDER <b># 4, SHELL ADAM - LONG, LOT PY, L2 T1, (6), AML, (ONL)</b>                |  |  |  |  |  |  |  |  |  | Df Corr                       |  | L5        |  | HOB Corr         |
| INITIAL FIRE COMMANDS <b>FM MF # 4 (6)</b>                                              |  |  |  |  |  |  |  |  |  | Rg                            |  | 5230      |  | SI +6            |
| Sp Instr <b>AML (ONL)</b>                                                               |  |  |  |  |  |  |  |  |  | SNDAM-L                       |  | Lot PY    |  | EI 367           |
| MTO                                                                                     |  |  |  |  |  |  |  |  |  | →T                            |  | PER       |  | QE 373           |
| Tgt Location Priority Firing Unit                                                       |  |  |  |  |  |  |  |  |  | PER                           |  | TF        |  | in Eff           |
| Dir, MF Sh, Fz Dev Rg HOB Corr                                                          |  |  |  |  |  |  |  |  |  | SUBSEQUENT FIRE COMMANDS      |  | AMMO      |  |                  |
| MF, Sh Chg, Fz FS Corr Ti Chart Df Df Corr Df Fired Chart Rg HOB Corr Si EI QE Exp Type |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| SR TR → 20.9                                                                            |  |  |  |  |  |  |  |  |  | 2484                          |  | L5        |  | (2484) 5250      |
| GFT SOLN: 20.6                                                                          |  |  |  |  |  |  |  |  |  |                               |  | 2489      |  | +6 369 (375) 485 |
| 20.9                                                                                    |  |  |  |  |  |  |  |  |  |                               |  |           |  | (375)            |
| TFT SOLN: -0.3 20.6                                                                     |  |  |  |  |  |  |  |  |  |                               |  |           |  | 486              |
| TBL B, COL 2                                                                            |  |  |  |  |  |  |  |  |  |                               |  | +111      |  | (TBL A, COL 2)   |
| FROM LINE 02 OF MET MESSAGE: WIND DIR 2100                                              |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| WIND SPEED 15 KNOTS                                                                     |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| F155 ADD-L-1: TBL A, COL 5: LOW LEVEL WIND CORR: 9.0 M/1 KNOT WIND                      |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| x 15 KNOTS                                                                              |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| 135 = 140 M (DISP FOR LOW LEVEL WIND)                                                   |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| ★ ORIENT TGT GRID TO DIR 2100, ADD +140 M, DETERMINE CHG RG & DF TO DISPLACED GRID.     |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| GFT A: CHG 4, LOT MY, RL 6080, PL 460, T1 25.5                                          |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| GFT: R2                                                                                 |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |
| Btry A DTG TODAY/NOV Tgt Replot Grid Replot Alt                                         |  |  |  |  |  |  |  |  |  |                               |  |           |  |                  |

DA FORM 4504 MAY 76 Replaces DA Form 3522, 1 Jan 74 and DA Form 4007, 1 Jan 73. For use of this form, see FM 6-40 and FM 6-40-3; the proponent agency is US Army Training and Doctrine Command.

Figure 11-9. Transfer method.

| RECORD OF FIRE                                                                          |  |  |  |  |  |  |  |  |  |                          |  |                |  |                  |
|-----------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------|--|----------------|--|------------------|
| Observer: CALL FOR FIRE AF/FFE/IS/S                                                     |  |  |  |  |  |  |  |  |  | Tgt                      |  | TGT: 317       |  | △ FS             |
| Grid: <b>AIMPOINT: 6533 3730</b>                                                        |  |  |  |  |  |  |  |  |  | BTRY: 365                |  | 100/R          |  |                  |
| Polar: Dir _____ Dis _____ U/D _____ VA ±                                               |  |  |  |  |  |  |  |  |  | VI: -38                  |  | /R             |  |                  |
| Shift: <b>RAAM - SHORT DESTRUCT, (12)</b>                                               |  |  |  |  |  |  |  |  |  | U/D                      |  | 20/R           |  |                  |
| FIRE ORDER <b># 3, SHELL RAAM - SHORT, LOT AY, L2 T1, (12)</b>                          |  |  |  |  |  |  |  |  |  | Df Corr                  |  |                |  | HOB Corr         |
| INITIAL FIRE COMMANDS <b>FM MF # 3 (12)</b>                                             |  |  |  |  |  |  |  |  |  | Rg                       |  | 6020           |  | EI               |
| Sp Instr                                                                                |  |  |  |  |  |  |  |  |  | SRAAM-1                  |  | Lot AY         |  | QE               |
| MTO                                                                                     |  |  |  |  |  |  |  |  |  | →T                       |  | PER            |  | TF               |
| Tgt Location Priority Firing Unit                                                       |  |  |  |  |  |  |  |  |  | PER                      |  | TF             |  | in Eff           |
| Dir, MF Sh, Fz Dev Rg HOB Corr                                                          |  |  |  |  |  |  |  |  |  | SUBSEQUENT FIRE COMMANDS |  | AMMO           |  |                  |
| MF, Sh Chg, Fz FS Corr Ti Chart Df Df Corr Df Fired Chart Rg HOB Corr Si EI QE Exp Type |  |  |  |  |  |  |  |  |  |                          |  |                |  |                  |
| FROM MET DATA CORR SHEET: (23.7)                                                        |  |  |  |  |  |  |  |  |  | 2497                     |  |                |  | (418) ← SR DATA  |
| (SOLN OF MET TO TGT)                                                                    |  |  |  |  |  |  |  |  |  |                          |  |                |  |                  |
| GFT SOLN: 21.9                                                                          |  |  |  |  |  |  |  |  |  | 2487                     |  |                |  | 433              |
| (23.7) ← ENTRY T1                                                                       |  |  |  |  |  |  |  |  |  |                          |  |                |  | (418) ← ENTRY DE |
| FIRING TBL F155-N-1: TFT SOLN: -1.7 22.0                                                |  |  |  |  |  |  |  |  |  |                          |  |                |  | 434              |
| TBL B, COL 2                                                                            |  |  |  |  |  |  |  |  |  | +16                      |  | (TBL A, COL 2) |  |                  |

Figure 11-10. Met + VE.

the artillery delivered minefield planning sheet immediately upon emplacement of a minefield. The information may be transmitted by secure voice.

(9) An explanation of the minefield planning sheet information to be forwarded is as follows:

—**TARGET NO.** The FDC records the minefield target number as designated by the artillery FSO/fire support element (FSE).

—**RANGE TO MINEFIELD CENTER.** The FDC first outlines the desired minefield limits as defined in section I. The minefield center is then determined and announced to the HCO, who plots it on his chart and then determines and announces the range to the minefield center.

—**TRAJECTORY.** The FDC selects low angle or high angle fire.

—**AIMPOINT COORDINATES.** The FDC determines and locates the required number of aimpoints to emplace the desired minefield. The grid location of each aimpoint is recorded on the record of fire.

—**NUMBER OF ROUNDS.** The FDC records the number of rounds expended on each aimpoint.

—**DTG MISSION EXECUTED.** The FDC records the date/time group that the minefield is emplaced.

—**DTG FORWARDED TO FSE.** The FDC records date/time group the FDC data was forwarded to the battalion/brigade FSE.

### 11-9. Field Artillery Employment Tables

a. The tables in the appropriate TFT are used by the field artillery to determine the number of aimpoints required to insure the emplacement of a given size minefield as detailed on the minefield planning sheet. To select the proper table, the FDC must determine the following:

(1) Delivery technique: Transfer, met + VE, or observer adjust.

(2) Shell: M718/M741 (RAAM) or M692/M731 (ADAM).

(3) Trajectory: Low angle or high angle fire.

(4) BMA.

b. Each table is constructed to coincide with a particular set of parameters as defined above. Once the correct table has been located, the entry arguments into each table are the range to the minefield center (expressed to the nearest 2000 meters) and the desired width of the minefield. The number of aimpoints required to emplace the minefield is then extracted from the middle of the table.

## Section II. ILLUMINATION

### 11-10. Characteristics and Employment

a. Illuminating projectiles are available for the 105-mm and the 155-mm howitzers

only. They are used for illuminating a designated area for the purpose of observing enemy night operations or adjusting artillery fires at night.

b. Illuminating projectiles are of the base ejection type. They are fired with a mechanical time fuze. The filler consists of an illuminating canister and parachute assembly. There are two models of illuminating projectiles for the 105-mm howitzer, the M314A2 model and the newer model M314A3 that functions the same but has a slight increase in burning time. The 155-mm howitzer also has two models. The M118 functions the same as the 105-mm illuminating projectile. The M485 model contains a drogue parachute that slows the forward speed of the projectile before the main chute is ejected and has a significant increase in illumination and burning time.

c. Illumination is conducted using the following techniques:

(1) The one-gun illumination pattern is used when effective illumination can be accomplished by firing one round at a time.

(2) The two-gun illumination pattern is used when an area requires more illumination than can be furnished by one gun.

(a) The two-gun illumination range spread pattern is used when the area to be illuminated has greater depth than width.

(b) The two-gun illumination lateral spread pattern is used when the area to be illuminated has greater width than depth.

(3) The four-gun illumination pattern is used to illuminate a large area. Four rounds are fired simultaneously in a diamond pattern.

## 11-11. Manual Solution Using GFT

a. *Illumination Graphical Firing Tables.* The illumination GFTs, like the GFTs for HE projectiles, simplify and speed up the work of the computer. The GFT is the simplest, most responsive method of computing illumination data. The ballistic scales of the 155-AM-1 illumination graphical firing table are described in (1) through (5) below. The scales of illumination GFTs for other

weapons are slightly different, since the 155-AM-1 is based on a 600-meter HOB. Other weapons are based on a 750-meter HOB.

(1) The 100/R scale is printed in red along the top edge of the rule. For a given range, the 100/R scale gives the correction necessary to shift the point of burst 100 meters laterally or vertically. The 100/R scale is read to the nearest mil.

(2) The range scale is located immediately below the 100/R scale. It is the basic scale on the illuminating GFT. All other scales are plotted with reference to the range scale. The range scale is read to the nearest 10 meters.

(3) The elevation-to-impact scale is located immediately below the range scale. When the hairline is placed over a given quadrant elevation on the elevation-to-impact scale, the range to the point of impact is read under the hairline on the range scale. This scale is used to determine the range to which a nonfunctioning projectile (dud) will travel.

(4) The 350- to 850-meter height-of-burst scales are located below the elevation-to-impact scale. These scales give the quadrant elevation for heights of burst in 50-meter increments from 350 meters to 850 meters above the battery. The quadrant elevation scale is graduated in mils and is read to the nearest mil. Figure 11-11 shows sample quadrant elevation readings for a height of burst of 600 meters.

(5) The fuze setting scale is located at the bottom of the scale and consists of a series of red arcs that are superimposed on the 350- to 850-meter height-of-burst quadrant elevation scales. The numbers represent fuze settings in increments of one fuze increment. The fuze setting scale is read to the nearest tenth at the intersection of the hairline and the selected quadrant elevation scale. Tenths are determined by interpolating between the fuze setting arcs that bracket the intersection of a hairline and the selected quadrant elevation scale.

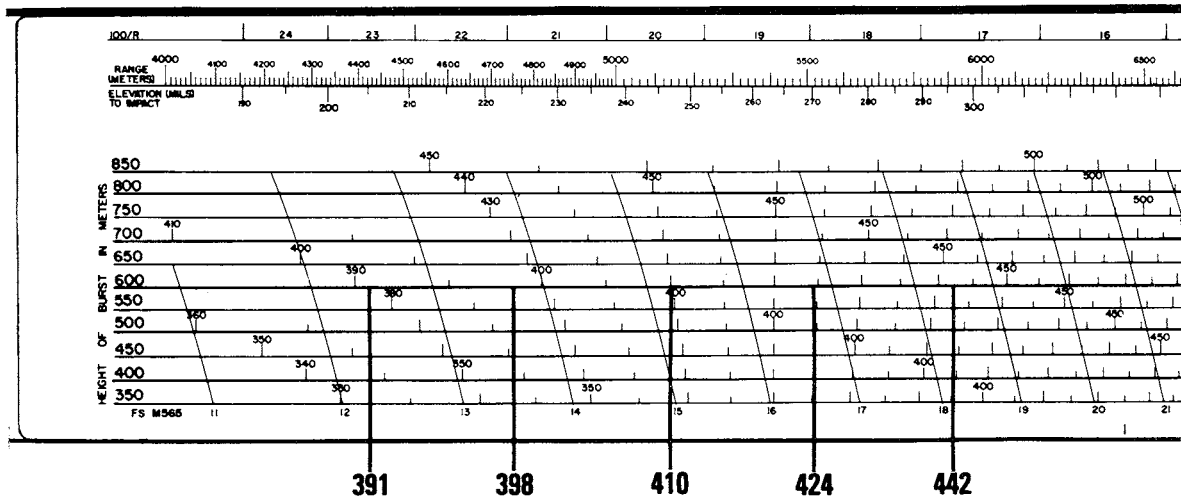


Figure 11-11. Illumination graphical firing tables (GFT).

*b. Selection of Charge.* Selection of the charge to fire is always a responsibility of the fire direction officer. However, a guideline to use when firing illumination is to choose the lowest practical charge to prevent a possible malfunction caused by the parachute ripping when the flare is ejected from the projectile.

*c. Determination of Quadrant Elevation.* When determining quadrant elevation and fuze setting from the GFT, it is important to

remember that data for the ascending branch is provided only for the lowest charge. A heavy black arrow on a quadrant elevation scale indicates the part of the trajectory that is at or near the summit and that does not exceed by 50 meters the height of burst that it represents. (Refer to figures 11-12 and 11-13.)

*d. GFT Setting for Illumination.* Because the M485 projectile is ballistically similar to

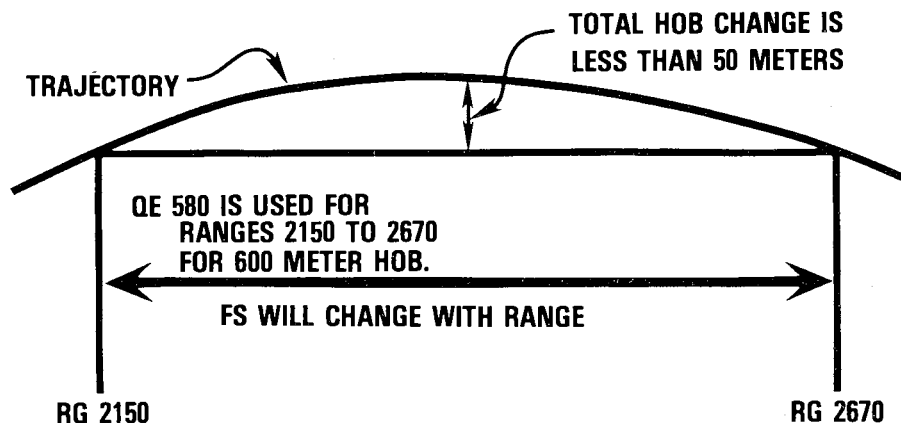


Figure 11-12. Trajectory of an illuminating projectile.

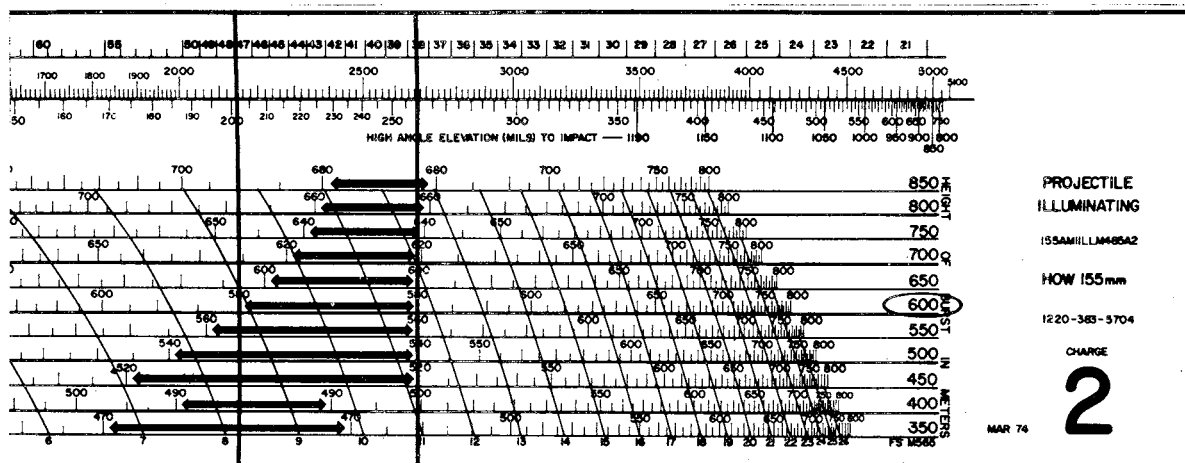


Figure 11-13. Summit bracket at 600 meters that does not exceed 50 meters in height of burst.

the M107 HE projectile, greater initial accuracy can be achieved by constructing a GFT setting (determined from an HE registration) on the illuminating scales. This is possible because the range scales are constructed logarithmically rather than linearly. The GFT setting geometrically applies a constant range  $K$  instead of the variable range  $K$  possible with slant-scale GFTs, but the error is negligible, considering the radius of illumination.

#### Example:

Given: Battery A, 155-mm howitzer (M109A1), has completed a registration with charge 5, projectile HE, and the following GFT setting has been determined: GFT A: Chg 5, Lot WY, Rg 6300, El 330.

Required: Construct a GFT setting for the illuminating GFT.

Solution: Place the hairline of the cursor over the adjusted elevation (330) on the elevation-to-impact scale; draw a range gageline on the range scale over the chart range (6300) to the registration point and mark this gageline "RG" (fig 11-14).

Application: To determine data, place the range gageline over the chart range and read the QE and FS under the hairline as follows:

Range: 7260 meters

Height of burst: 600 meters

Read: QE 535; FS 25.7.

Deflection corrections obtained from an HE registration are not used in determining data for the illumination projectile.

*e. Determination of Firing Data.* Just as in an HE mission, the target is plotted and chart data determined. The VCO determines the vertical interval between the battery and the ground level in the area to be illuminated and announces it to the computer who determines the fuze setting, deflection, and quadrant to fire as follows:

#### (1) Fuze setting.

(a) Set the range gageline over the announced chart range if using a GFT setting. If no GFT setting is available, use the MHL.

(b) Select the appropriate height of burst scale by applying the VI (expressed to the nearest 50 meters) to the optimum HOB (600 meters). For example: VI is +38 expressed to +50; applied to the optimum HOB of 600 meters would be the 650-meter HOB scale ( $600 + 50 = 650$ ). A negative VI of -38 would be expressed to -50; applied to the optimum HOB of 600 meters would be the 550-meter HOB scale ( $600 + (-50)$ ).

(c) Determine the fuze setting by visually interpolating between the red fuze

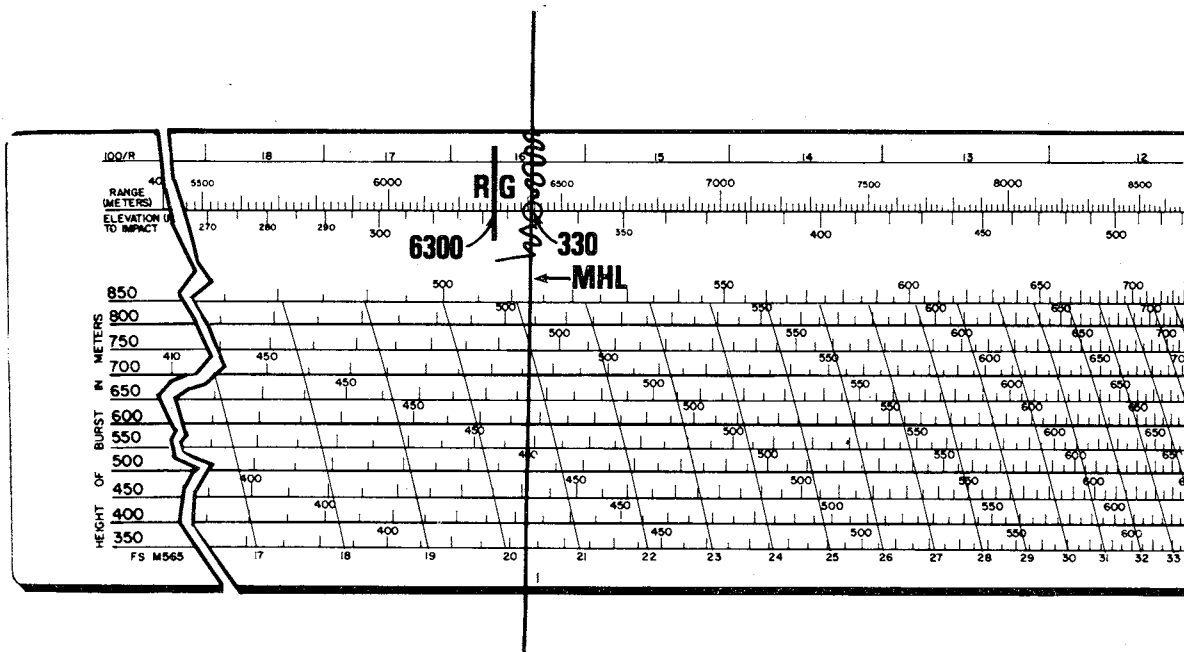


Figure 11-14. Placing a GFT setting on an illumination GFT.

setting arcs for the point of intersection of the hairline and the selected quadrant elevation scale. Read to the nearest tenth.

(d) The range at which the fuze setting is determined depends on the method of engagement.

1. When one-gun or two-gun illumination is used, the fuze setting is based on the chart range.

2. When two-gun illumination, range spread, is used, the fuze setting for one piece is based on the chart range plus 500 meters; for the other piece, on the chart range minus 500 meters.

3. When two-gun illumination, lateral spread, is used, the fuze setting for both pieces is based on the chart range.

4. When four-gun illumination, range and lateral spread, is used, the fuze settings for the flank pieces are based on the chart range; for one of the interior pieces, on the chart range plus 500 meters; and for the other interior piece, on the chart range minus 500 meters. When the M118 or 105-mm illuminating projectiles are being fired, 400 meters, instead of 500 meters, is applied to the chart range.

(2) *Deflection.* Deflection corrections determined from firing shell HE are disregarded. The deflection to be fired depends on the method of engagement.

(a) When one-gun or two-gun illumination is used, the chart deflection is fired.

(b) When two-gun illumination, range spread, is used, the chart deflection is fired.

(c) When two-gun illumination, lateral spread, is used, the chart deflection minus 5 times 100/R is fired by the right piece and the chart deflection plus 5 times 100/R is fired by the left piece.

(d) When four-gun illumination is used, both range and lateral spread are fired. The chart deflection is fired by the two interior pieces, the chart deflection minus 5 times 100/R is fired by the right flank piece, and the chart deflection plus 5 times 100/R is fired by the left flank piece. When the M118 illuminating projectile or the 105-mm projectile is being fired, 4 times 100/R, instead of 5 times 100/R, is applied to the chart deflection for a lateral spread because

the desired distance between bursts is 800 meters.

(3) *Quadrant elevation.*

(a) Set the range gageline or MHL if no GFT setting is available over the chart range.

(b) Read the quadrant elevation to the nearest mil at the intersection of the MHL and the selected quadrant elevation scale for the HOB.

(c) The range at which the quadrant elevation is determined depends on the method of engagement.

1. When one-gun or two-gun illumination is used, the quadrant elevation is based on the chart range.

2. When two-gun illumination, range spread, is used, the quadrant elevation for one piece is based on the chart range plus 500 meters; for the other piece, on the chart range minus 500 meters.

3. When two-gun illumination, lateral spread, is used, the quadrant elevation for both pieces is based on the chart range.

4. When four-gun illumination, range and lateral spread, is used, the quadrant elevations and fuze settings for the flank pieces are based on the chart range; for one of the interior pieces, on the chart range plus 500 meters; and for the other interior piece, on the chart range minus 500 meters. When the M118 illuminating projectile or 105-mm projectiles are being fired, 400 meters, instead of 500 meters, is applied to the chart range.

(4) *Subsequent corrections.*

(a) *Range and deviation corrections only.* When the observer sends range and/or deviation corrections, firing data is determined by first plotting the correction on the chart, insuring that the correction is made from the initial target location on the observer's direction, and determining a new chart range and deflection. Illumination firing data is then determined as previously discussed.

(b) *Height-of-burst correction.* When the observer includes an HOB correction, the quadrant elevation and fuze settings for subsequent rounds are determined as discussed above except that for each subsequent fire command the observer HOB

correction (always given in multiples of 50 meters) is applied to the height of burst used for the previous round(s). The new height-of-burst scale is used to determine the QE and fuze setting.

*Example:*

The following problem illustrates the procedures for firing illumination. Although the M485A2 projectile and illumination scales prepared for the M109A1 howitzer are used in the example, these procedures are applicable for all weapons firing illumination.

a. *Known Data for Battery B, M109A1 howitzer.*

GFT setting: None

Lot S is Green Bag.

Lot P is shell illuminating M485A2.

b. *Situation.* The following call for fire has been received in the FDC:

**P36 THIS IS P27, ADJUST FIRE, OVER.**

**GRID 638 326, OVER.**

**SUSPECTED VEHICLES, ILLUMINATION, OVER.**

c. *FDC Procedures.*

(1) *Fire order:*

NUMBER 6, SHELL ILLUMINATION,  
LOT PAPA SIERRA, CHARGE 5,  
FUZE TIME.

(2) *HCO data:*

BRAVO RANGE 7430, DEFLECTION  
3186.

(3) *VCO data:*

VERTICAL INTERVAL +80.

d. *Determination of Firing Data.*

(1) *Vertical interval.* The computer expresses the vertical interval to the nearest 50 meters and applies the result to the desired height of burst of 600 meters.

|                          |      |
|--------------------------|------|
| Desired HOB above target | 600  |
| Vertical interval        | +100 |
| HOB                      | 700  |



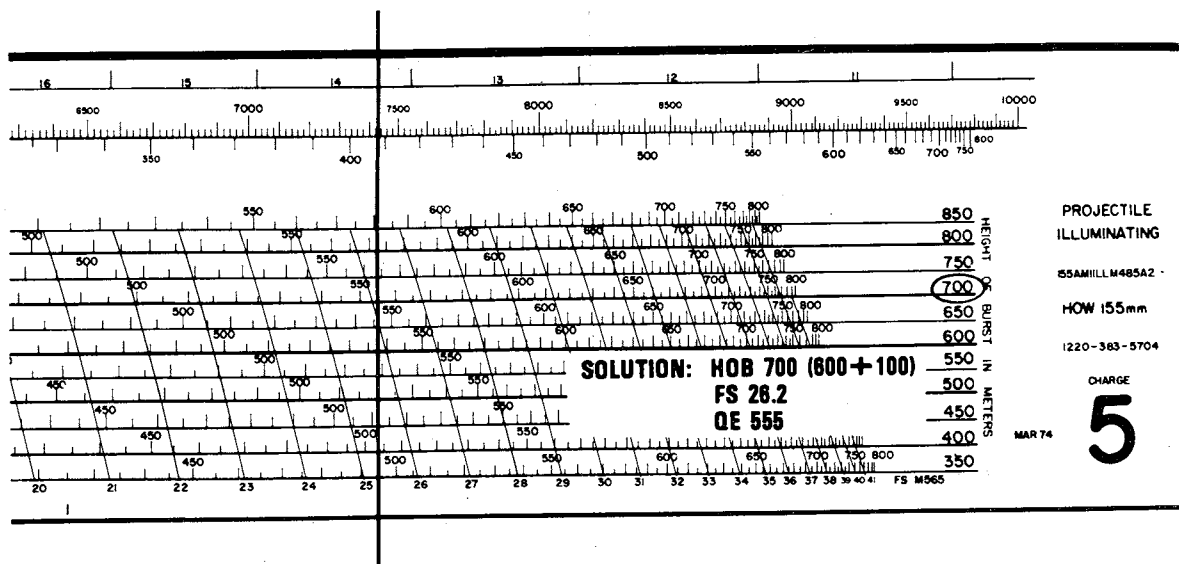


Figure 11-15. Determination of firing data (illumination).

(2) *Fuze setting.* Place the MHL over range 7430, and determine the fuze setting by interpolating between the red fuze setting arcs that bracket the intersection of the hairline and the 700-meter height-of-burst scale (fig 11-15).

Time: 26.2

(3) *Deflection.* The chart deflection is the deflection to fire.

Deflection: 3186

(4) *Quadrant elevation.* Place the MHL over range 7430 and determine the QE where the hairline crosses the 700-meter height-of-burst scale.

Quadrant: 555

*e. Situation Continued (HOB Correction).*

(1) *Observer corrections:*

**DIRECTION 150, RANGE AND LATERAL SPREAD, RIGHT 350, ADD 400, UP 100, OVER.**

The observer has now asked for range and lateral spread, thereby upgrading the mission to four guns.

(2) *HCO data:*

**BRAVO RANGE 7180, DEFLECTION 3179.**

(3) The computer must now change the method of fire for the guns:

**RIGHT AND LEFT ADJUST, AT MY COMMAND, SPECIAL CORRECTIONS, SHELL ILLUMINATION, LOT PAPA SIERRA, CHARGE 5, FUZE TIME.**

The initial fire commands must be given to all four guns now involved in the mission, since only No. 6 was following the mission initially.

*f. Determination of Firing Data.*

(1) The computer applies the HOB correction to the previous height of burst:

|                |            |
|----------------|------------|
| Previous HOB   | 700        |
| HOB correction | + 100      |
| HOB            | <u>800</u> |

(2) After the chart data is announced, the computer must determine the range at which each piece will fire. In this example No. 1 will fire the right limit, No. 6 will fire the left limit, No. 2 will fire the greater range, and No. 5 will fire the shorter range. The ranges for each weapon are determined as follows:

# C1, FM 6-40

|                 |                    |       |
|-----------------|--------------------|-------|
| Number 1        | Number 2           |       |
| No range change | Chart range        | 7180  |
|                 | + Range correction | + 500 |
|                 | Range No. 2        | 7680  |

|                 |                    |       |
|-----------------|--------------------|-------|
| Number 6        | Number 5           |       |
| No range change | Chart range        | 7180  |
|                 | - Range correction | - 500 |
|                 | Range No. 5        | 6680  |

(3) The fuze settings are determined as follows:

(a) *No. 1 and No. 6.* Place the MHL over range 7180, and determine the fuze setting where the hairline crosses the 800-meter height-of-burst scale:

No. 1 time 25.0

No. 6 time 25.0

(b) *No. 2.* Place the MHL over range 7680, and determine the fuze setting where the hairline crosses the 800-meter height-of-burst scale:

No 2 time 27.9

(c) *No. 5.* Place the MHL over range 6680, and determine the fuze setting where the hairline crosses the 800-meter height-of-burst scale:

No. 5 time 22.4

(4) Deflection is determined as follows: The value for 100/R at the initial chart range is 14 mils.

(a) *No. 1.* Determine the deflection to fire by applying a RIGHT 70 (500/R) to the chart deflection.

|          |      |
|----------|------|
| Chart df | 3179 |
| - 500/R  | R70  |
| No. 1 df | 3109 |

(b) *No. 2 and No. 5.* The chart deflection is fired.

No. 2 deflection 3179

No. 5 deflection 3179

(c) *No. 6.* Determine the deflection by applying a LEFT 70 (500/R) to the chart deflection.

|          |      |
|----------|------|
| Chart df | 3179 |
| + 500/R  | L70  |
| No. 6 df | 3249 |

(5) Quadrant elevation is determined as follows:

(a) *No. 1 and No. 6.* Place the MHL over range 7180 and determine the QE where the hairline crosses the 800-meter height-of-burst scale:

No. 1 Quadrant 553

No. 6 Quadrant 553

(b) *No. 2.* Place the MHL over range 7680, and determine the QE where the hairline crosses the 800-meter height-of-burst scale:

No. 2 Quadrant 595

(c) *No. 5.* Place the MHL over range 6680, and determine the QE where the hairline crosses the 800-meter height-of-burst scale:

No. 5 Quadrant 519

## 11-12. Manual Solution Using TFT

Part II of the standard TFT for each weapon can be used in computing illuminating data. The illumination TFT consists of one table used to compute initial data and data for any subsequent corrections. In converting chart data to firing data, the computer must consider the type of adjustment.

### a. Determination of Firing Data.

(1) *Deflection.* The deflection to fire is determined using the same procedures as with the GFT solution outlined in paragraph 11-11.

(2) *Fuze setting and quadrant elevation.* For each 100 meters in range (column 1), the firing tables (fig 11-16) show the quadrant elevation (column 2) and fuze setting (column 3) for the optimum height of burst (600 meters), and the change in elevation and fuze setting for a 50-meter change in height of burst (columns 4 and 5). In computing initial data, the VI is expressed to the nearest 50 meters and the appropriate corrections for QE and fuze setting are selected and applied to the data listed. Site is ignored. The range used for each piece is determined using the same procedure as with the GFT solution outlined in paragraph 11-11. (Chart range to the nearest 100 meters is used to determine data from the tabular firing tables.)

FT 155-AM-1

CHARGE  
5GPROJ, ILLUMINATING, M485A2  
FUZE, RT, M565

| 1                     | 2            | 3    | 4                                                                      | 5    | 6                               | 7                     |
|-----------------------|--------------|------|------------------------------------------------------------------------|------|---------------------------------|-----------------------|
| RANGE<br>TO<br>TARGET | QUAD<br>ELEV | FS   | CHANGE IN<br>QE FS<br>FOR AN INCREASE<br>OF 50 M IN<br>HEIGHT OF BURST |      | RANGE<br>TO<br>FUZE<br>FUNCTION | RANGE<br>TO<br>IMPACT |
| M                     | MIL          | FS   | MIL                                                                    | FS   | M                               | M                     |
| 4500                  | 392.2        | 12.8 | 11.5                                                                   | 0.06 | 3884                            | 7238                  |
| 4600                  | 394.4        | 13.1 | 11.3                                                                   | 0.06 | 3987                            | 7265                  |
| 4700                  | 396.8        | 13.5 | 11.1                                                                   | 0.06 | 4090                            | 7295                  |
| 4800                  | 399.5        | 13.9 | 10.9                                                                   | 0.06 | 4192                            | 7328                  |
| 4900                  | 402.4        | 14.3 | 10.7                                                                   | 0.06 | 4295                            | 7363                  |
| 5000                  | 405.4        | 14.7 | 10.6                                                                   | 0.06 | 4398                            | 7400                  |
| 5100                  | 408.7        | 15.1 | 10.4                                                                   | 0.07 | 4500                            | 7439                  |
| 5200                  | 412.2        | 15.5 | 10.2                                                                   | 0.07 | 4603                            | 7480                  |
| 5300                  | 415.8        | 15.9 | 10.1                                                                   | 0.07 | 4706                            | 7522                  |
| 5400                  | 419.6        | 16.3 | 10.0                                                                   | 0.07 | 4809                            | 7567                  |
| 5500                  | 423.6        | 16.7 | 9.8                                                                    | 0.07 | 4912                            | 7613                  |
| 5600                  | 427.8        | 17.1 | 9.7                                                                    | 0.07 | 5015                            | 7661                  |
| 5700                  | 432.2        | 17.6 | 9.6                                                                    | 0.07 | 5118                            | 7710                  |
| 5800                  | 436.7        | 18.0 | 9.5                                                                    | 0.08 | 5221                            | 7761                  |
| 5900                  | 441.4        | 18.4 | 9.4                                                                    | 0.08 | 5324                            | 7813                  |
| 6000                  | 446.3        | 18.9 | 9.3                                                                    | 0.08 | 5427                            | 7867                  |
| 6100                  | 451.4        | 19.3 | 9.2                                                                    | 0.08 | 5530                            | 7921                  |
| 6200                  | 456.7        | 19.8 | 9.1                                                                    | 0.08 | 5634                            | 7977                  |
| 6300                  | 462.1        | 20.2 | 9.0                                                                    | 0.09 | 5737                            | 8034                  |
| 6400                  | 467.8        | 20.7 | 8.9                                                                    | 0.09 | 5840                            | 8092                  |
| 6500                  | 473.6        | 21.2 | 8.9                                                                    | 0.09 | 5943                            | 8151                  |
| 6600                  | 479.6        | 21.6 | 8.8                                                                    | 0.09 | 6047                            | 8210                  |
| 6700                  | 485.8        | 22.1 | 8.7                                                                    | 0.10 | 6150                            | 8271                  |
| 6800                  | 492.3        | 22.6 | 8.7                                                                    | 0.10 | 6254                            | 8333                  |
| 6900                  | 498.9        | 23.1 | 8.7                                                                    | 0.10 | 6357                            | 8395                  |
| 7000                  | 505.8        | 23.6 | 8.6                                                                    | 0.11 | 6461                            | 8458                  |
| 7100                  | 512.9        | 24.1 | 8.6                                                                    | 0.11 | 6565                            | 8522                  |
| 7200                  | 520.3        | 24.6 | 8.6                                                                    | 0.11 | 6668                            | 8586                  |
| 7300                  | 527.9        | 25.2 | 8.6                                                                    | 0.12 | 6772                            | 8651                  |
| 7400                  | 535.8        | 25.7 | 8.6                                                                    | 0.12 | 6876                            | 8717                  |
| 7500                  | 544.0        | 26.3 | 8.6                                                                    | 0.13 | 6980                            | 8783                  |
| 7600                  | 552.5        | 26.9 | 8.6                                                                    | 0.14 | 7084                            | 8849                  |
| 7700                  | 561.4        | 27.5 | 8.7                                                                    |      | 7188                            | 8916                  |
| 7800                  |              | 28.1 | 8.7                                                                    |      | 7293                            | 8983                  |
| 7900                  |              | 28.7 | 8.7                                                                    |      |                                 |                       |

Figure 11-16. Manual solution using TFT.

(3) *Height-of-burst correction.* Height-of-burst corrections are made in increments of 50 meters. The total height-of-burst correction is determined by adding the cumulative height-of-burst correction and the vertical interval expressed to the nearest 50 meters. The corrections to quadrant elevation and fuze setting are determined as follows:

(a) Divide the total height-of-burst correction by 50 to determine the number of 50-meter increments.

(b) Determine the value listed as change in QE and change in fuze setting for a 50-meter change in height of burst from columns 4 and 5 of the firing tables.

(c) Multiply the number of 50-meter increments obtained as in (a) above by the values obtained as in (b) above.

(4) *Fuze setting and quadrant elevation.* The fuze setting to be fired is the sum of the fuze setting ((2) above) and the fuze setting

correction for height of burst ((3) above). The quadrant elevation to be fired is the sum of the QE ((2) above) and the QE correction for height of burst ((3) above).

### 11-13. Coordinated Illumination

#### a. Illumination Mark.

(1) When the observer requests **COORDINATED ILLUMINATION**, the FDC will control the firing of the HE so that it detonates at the time of maximum illumination. When the illuminating projectile is fired, the FDC will initiate a stopwatch to determine the time to maximum illumination. This point will be designated by the observer when he announces **ILLUMINATION MARK**. The stopwatch will then be stopped. The time indicated is the time of flight of the projectile to maximum light. Compare this time with the HE time of flight to determine when to fire the HE. All times used will be expressed to the nearest second.

#### (2) Example follows:

Time to maximum illumination

(stopwatch):

64

- HE time of flight (GFT or FADAC): - 18

Difference

46

Fire the HE 46 seconds after firing the illuminating projectile.

(3) The illumination mark method of engagement contains the element of surprise to the target and is effective in achieving surprise.

b. *By Shell at My Command.* An alternate method is by shell at my command. This indicates that both the HE and illuminating rounds are to be fired at the FO's command. As soon as the FDC reports that the illuminating and HE fires are ready and gives the time of flight for each projectile, the FO can give the command to fire. The FO commands the illuminating round be fired and then the HE rounds so that the HE rounds will arrive during the period of maximum illumination of the target. The shell at my command method of engagement

Table 11-7. Employment Factors for Illuminating Shells

## EMPLOYMENT FACTORS FOR ILLUMINATING SHELLS

| CANNON | PROJECTILE | INITIAL HEIGHT<br>OF BURST<br>(METERS) | DISTANCE BETWEEN<br>BURSTS (SPREAD)<br>(METERS) | BURNING TIME<br>(SECONDS) | RATE OF CONTINUOUS<br>ILLUMINATION (ROUNDS<br>PER MINUTE) | RATE OF FALL<br>(METERS PER<br>SECOND) |
|--------|------------|----------------------------------------|-------------------------------------------------|---------------------------|-----------------------------------------------------------|----------------------------------------|
| 105mm  | M314A2     | 750                                    | 800                                             | 60                        | 2                                                         | 10                                     |
| 105mm  | M314A2     | 750                                    | 800                                             | 70-75                     | 2                                                         | 10                                     |
| 155mm  | M118       | 750                                    | 800                                             | 60                        | 2                                                         | 10                                     |
| 155mm  | M485A2     | 600                                    | 1000                                            | 120                       | 1                                                         | 5                                      |

is excellent when the FO wants to achieve surprise.

*c. Continuous Illumination.* When attacking and destroying a target is more important than conservation of ammunition, continuous illumination can be used. Using table 11-7 for the appropriate caliber, the rounds per minute to be fired can be determined.

#### 11-14. FADAC Procedures

*a.* After mission data has been entered into FADAC, firing data for illumination projectiles may be computed by simply

designating the appropriate projectile and fuze.

*b.* The correct height of burst is automatically computed.

*c.* Because of the complexity of the FADAC computed trajectory, the operator should not override the charge when computing initial data. After initial data has been displayed, the FADAC selected charge will be entered and used throughout the mission.

*d.* When conducting coordinated illumination missions, it is preferred to compute the illumination data manually and use FADAC to compute the other shell.

## Section III. WHITE PHOSPHORUS

#### 11-15. Characteristics and Employment

Several projectiles require corrections to firing data because of variations in weights. These include the 105-mm and 155-mm white phosphorus (WP) projectile. White phosphorus is a bursting type of smoke shell that produces smoke, incendiary, and casualty effects. Against most targets, super-quick fuze action is used. The action of the fuze and burster charge breaks the projectile and scatters the phosphorus particles above the ground. White phosphorus is also used for smokescreens and as a marking round.

#### 11-16. Manual Solution Using GFT and TFT

The manual solution incorporates the use of the GFT and the TFT. Corrections must be made to HE firing data to compensate for the weight difference between the HE and WP. The TFT solution provides corrections to the range to compensate for the weight difference. When fire for effect is to be fired with white phosphorus, the adjustment phase is normally conducted with HE, fuze quick. Data is determined as follows:

*a. Chart Data.* Chart range, deflection,

and site are determined in the normal manner.

*b. Fuze Setting.* Normally the WP round is fired with fuze quick. When fired with fuze time, the fuze setting is determined from the time gageline using the range that is corrected to compensate for the difference in projectile weights.

*c. Deflection.* The piece deflection determined for the WP projectile is the same as that determined for HE. During an adjust fire mission (HE in adjustment, WP in effect), the deflection correction is determined and applied as usual; i.e., drift is determined corresponding to the initial HE elevation and applied to the GFT deflection correction. The resulting deflection correction does not change throughout the mission. In a fire for effect mission with shell WP, the drift will be determined after the weight correction has been computed and applied. Drift, then, will be determined corresponding to the WP elevation and applied to the GFT deflection correction in the normal manner.

*d. Quadrant Elevation.*

(1) Determine the difference in the weights (squares) of the projectiles by subtracting the weight of the HE used in adjustment from the weight of the white phosphorus.

(2) From table F of the appropriate TFT, determine the correction for an increase or decrease in projectile weight of one square. Use initial chart range expressed to the nearest 100 meters for entry into table F.

(3) Determine the correction by multiplying the difference in projectile weight ((1) above) by the unit correction ((2) above).

(4) Apply the correction expressed to nearest 10 meters to the fire for effect chart range. Place the hairline of the GFT over the corrected range and read the elevation under the elevation gageline. Apply site to the elevation to determine the quadrant elevation.

*e. Weight Correction.* The correction for

the weight of the projectile is considered constant for a particular mission and need not be recomputed during any subsequent adjustment.

*Example:*

The following problem illustrates the procedures for firing white phosphorus. Although the M110A2 projectile, GFT HE 107 scales, and FT 155-AM-1 prepared for the M109A1 howitzer are used in the example, these procedures are applicable for all weapons firing white phosphorus.

*a. Known Data for Battery B, M109A1 Howitzer.*

GFT: GFT B: Chg 4, Lot XY, Rg 5260, El 329, Ti 19.2

GFT df corr: L1

Lot Y is Green Bag.

Lot R is shell WP M110A2.

WP weight 6 ☐

HE weight 4 ☐

*b. Situation.* The following call for fire has been received in the FDC:

**P28, THIS IS P36, FIRE FOR EFFECT, OVER.**

**GRID 627 292, OVER.**

**FOUR TRUCKS REFUELING, WP, OVER.**

*c. Situation Continued.*

(1) Fire order:

**FIRE FOR EFFECT, SHELL WP, LOT ROMEO YANKEE, THREE ROUNDS.**

(2) HCO data:

**BRAVO RANGE 5340, DEFLECTION 3242.**

(3) VCO data:

**SITE BRAVO PLUS 3.**

(4) Initial fire commands:

**BATTERY THREE ROUNDS, SHELL WP, LOT ROMEO YANKEE, CHARGE**

**4.**

*d. Determination of Corrected Range.*

- (1) The difference in weight is 2 squares.

$$\begin{array}{r}
 \text{WP} \\
 - \text{HE} \\
 \hline
 \text{WT}
 \end{array}
 \begin{array}{r}
 6 \square \\
 4 \square \\
 \hline
 +2 \square
 \end{array}$$

(2) From table F (fig 11-17), charge 4GB, enter with the initial chart range expressed to the nearest 100 meters (5340 ≈ 5300). Complementary range is not considered. Extract from the column headed "Proj WT of 1 SQ, INC" the value of +39.

(3) Multiply the difference in weight (2 squares) by the unit correction (+39) and express to the nearest 10 meters.

$$+39 \times 2 = +78 \approx +80$$

(4) Apply the correction (+80 meters) to the fire for effect chart range (5340) to determine the corrected range.

$$5340 + 80 = 5420.$$

*e. Determination of Firing Data.*

(1) *Deflection.* The piece deflection fired is the chart deflection (3242) + the GFT deflection correction (L1) + drift (L7) = deflection 3250. The drift is determined at the elevation corresponding to the corrected range.

(2) *Quadrant elevation.* Place the MHL of the GFT over the corrected range (5420) and read the elevation under the elevation gageline (342). Apply site to determine the quadrant to fire.

$$\begin{array}{r}
 \text{Elevation} \\
 + \text{Site} \\
 \hline
 \text{QE}
 \end{array}
 \begin{array}{r}
 342 \\
 +3 \\
 \hline
 345
 \end{array}$$

PT 155-AH-1

TABLE F

CHARGE  
4GPROJ, HE, M107  
FUZE, PD, M557

CORRECTION FACTORS

| 1                     | 10                          | 11    | 12                      | 13   | 14                   | 15   | 16                      | 17  | 18                               | 19  |
|-----------------------|-----------------------------|-------|-------------------------|------|----------------------|------|-------------------------|-----|----------------------------------|-----|
| R<br>A<br>N<br>G<br>E | RANGE CORRECTIONS FOR       |       |                         |      |                      |      |                         |     |                                  |     |
|                       | MUZZLE<br>VELOCITY<br>1 M/S |       | RANGE<br>WIND<br>1 KNOT |      | AIR<br>TEMP<br>1 PCT |      | AIR<br>DENSITY<br>1 PCT |     | PROJ WT<br>OF 1 SQ<br>(4 SQ STD) |     |
|                       | DEC                         | INC   | HEAD                    | TAIL | DEC                  | INC  | DEC                     | INC | DEC                              | INC |
|                       | M                           | M     | M                       | M    | M                    | M    | M                       | M   | M                                | M   |
| 3500                  | 19.8                        | -15.2 | 4.4                     | -1.1 | 9.3                  | -1.5 | -2.8                    | 2.9 | -26                              | 28  |
| 3600                  | 20.3                        | -15.6 | 4.6                     | -1.2 | 9.5                  | -1.5 | -3.0                    | 3.2 | -27                              | 29  |
| 3700                  | 20.8                        | -16.0 | 4.7                     | -1.2 | 9.8                  | -1.5 | -3.2                    | 3.4 | -28                              | 30  |
| 3800                  | 21.4                        | -16.4 | 4.9                     | -1.3 | 10.0                 | -1.6 | -3.3                    | 3.4 | -28                              | 31  |
| 3900                  | 21.9                        | -16.8 | 5.0                     | -1.3 | 10.2                 | -1.6 | -3.5                    | 3.5 | -28                              | 31  |
| 4000                  | 22.4                        | -17.2 | 5.1                     | -1.4 | 10.5                 | -1.6 | -3.7                    | 3.7 | -29                              | 31  |
| 4100                  | 22.9                        | -17.6 | 5.3                     | -1.5 | 10.7                 | -1.7 | -3.8                    | 3.9 | -29                              | 32  |
| 4200                  | 23.4                        | -18.0 | 5.4                     | -1.5 | 10.9                 | -1.7 | -4.0                    | 4.1 | -30                              | 33  |
| 4300                  | 23.9                        | -18.4 | 5.6                     | -1.6 | 11.1                 | -1.7 | -4.2                    | 4.3 | -30                              | 33  |
| 4400                  | 24.4                        | -18.8 | 5.7                     | -1.6 | 11.3                 | -1.8 | -4.4                    | 4.5 | -31                              | 34  |
| 4500                  | 24.9                        | -19.2 | 5.9                     | -1.7 | 11.5                 | -1.8 | -4.6                    | 4.7 | -31                              | 34  |
| 4600                  | 25.4                        | -19.6 | 6.0                     | -1.8 | 11.7                 | -1.8 | -4.8                    | 4.9 | -32                              | 35  |
| 4700                  | 26.0                        | -20.0 | 6.1                     | -1.8 | 11.9                 | -1.8 | -5.0                    | 5.1 | -32                              | 36  |
| 4800                  | 26.5                        | -20.4 | 6.3                     | -1.9 | 12.0                 | -1.9 | -5.2                    | 5.3 | -33                              | 36  |
| 4900                  | 27.0                        | -20.8 | 6.4                     | -2.0 | 12.2                 | -1.9 | -5.4                    | 5.5 | -33                              | 37  |
| 5000                  | 27.5                        | -21.2 | 6.5                     | -2.0 | 12.4                 | -1.9 | -5.6                    | 5.7 | -34                              | 37  |
| 5100                  | 28.0                        | -21.6 | 6.7                     | -2.1 | 12.5                 | -1.9 | -5.8                    | 5.9 | -35                              | 38  |
| 5200                  | 28.5                        | -22.0 | 6.8                     | -2.2 | 12.7                 | -1.9 | -6.1                    | 6.2 | -35                              | 38  |
| 5300                  | 29.0                        | -22.4 | 6.9                     | -2.2 | 12.9                 | -2.0 | -6.3                    | 6.4 | -36                              | 39  |
| 5400                  | 29.4                        | -22.8 | 7.1                     | -2.3 | 13.0                 | -2.0 | -6.5                    | 6.6 | -36                              | 39  |
| 5500                  | 29.9                        | -23.2 | 7.2                     | -2.4 | 13.2                 | -2.0 | -6.8                    | 6.9 | -36                              | 40  |
| 5600                  | 30.4                        | -23.6 | 7.3                     | -2.5 | 13.3                 | -2.0 | -7.0                    | 7.1 | -37                              | 41  |
| 5700                  | 30.9                        | -24.1 | 7.4                     | -2.5 | 13.4                 | -2.0 | -7.2                    | 7.4 | -37                              | 41  |
| 5800                  | 31.4                        | -24.5 | 7.6                     | -2.6 | 13.6                 | -2.0 | -7.5                    | 7.6 | -38                              | 42  |
| 5900                  | 31.9                        | -24.9 | 7.7                     | -2.7 | 13.7                 | -2.1 | -7.7                    | 7.9 | -38                              | 42  |
| 6000                  | 32.4                        | -25.3 | 7.8                     | -2.7 | 13.8                 | -2.1 | -8.0                    | 8.1 | -39                              | 43  |
| 6100                  | 32.9                        | -25.7 | 7.9                     | -2.8 | 14.0                 | -2.1 | -8.2                    | 8.3 | -39                              | 43  |

Figure 11-17. Determination of corrected range for a change in projectile weight.

**11-17. FADAC Procedures**

a. The WP mission can be computed quickly and accurately with FADAC by simply designating the correct projectile (WP) and fuze (quick) to fire.

b. FADAC will automatically compute and apply the range correction for the weight difference between HE and WP.

## Section IV. SMOKE

**11-18. Characteristics and Employment**

HC (white) smoke is a base-ejection projectile fired with mechanical time fuze, M501A1, and is used to screen friendly movements

from the enemy or to obscure the enemy's vision. It produces no casualty effect. Immediate smoke is a fire for effect type mission used against targets 0 to 150 meters in width. Quick smoke is an adjust fire type mission for targets 150 to 600 meters in width.

# 11-19. Manual Solution Using GFT (Immediate Smoke)

Immediate smoke is fired with a high degree of urgency and demands immediate response in the FDC. It may be fired as a separate mission or as a followup to immediate suppression. Normally, this mission will be fired by one platoon, with one gun firing shell WP, fuze quick and the other gun firing shell smoke, fuze time on the first volley. Unit SOP should dictate the number of volleys fired in an immediate smoke mission and also which gun will fire the WP and which one will fire the smoke on the first volley; e.g., odd-numbered gun fires WP and even-numbered gun fires smoke. The platoon that will normally fire immediate smoke missions may also be stated in the SOP. Firing data is determined as follows:

*a. Chart Data.* Chart data and deflection and site are determined in the normal manner.

*b. WP Data.* For immediate smoke missions, firing data is determined using the procedures in paragraph 11-16, except that the difference in projectile weight is ignored.

*c. Smoke Data.*

(1) *Fuze setting.* Place the MHL of the GFT over the chart range and read an M564 fuze setting under the time gageline. Subtract 2.0 from this fuze setting to determine the fuze setting to fire. Subtracting 2.0 from the M564 fuze settings provides the appropriate height of burst (approximately 100 meters) for the smoke.

(2) *Deflection.* The deflection to fire is the chart deflection plus the total deflection correction.

(3) *Quadrant elevation.* Place the MHL of the GFT over the chart range and read the elevation under the elevation gageline. Apply average site to the elevation to determine the quadrant to fire. (Do not apply 20/R.)

## Example (Immediate Smoke):

The following problem illustrates the procedures for firing immediate smoke.

Although the M116B1 (smoke) and M110 (WP) projectiles and HE107 scales prepared M109A1 howitzer are used in the example, these procedures are applicable for all weapons firing projectiles WP and smoke.

*a. Known Data for M109A1.*

GFT: GFT B: Chg 4, Lot XY, Rg 6080, El 402, Ti 23.3

Total df corr: L7

GFT df corr: R2

Lot Y is Green Bag.

Lot R is White Phosphorus.

Lot V is Smoke.

Unit SOP states that the odd-numbered gun will fire WP/Q and the even-numbered gun will fire SMK/TI in the first volley of immediate smoke.

*b. Situation.* The following call for fire has been received in the FDC:

**THIS IS P51, IMMEDIATE SMOKE, GRID 625 371, OVER.**

*c. Situation Continued.*

(1) Fire order:

**IMMEDIATE SMOKE, RIGHT, THREE ROUNDS.**

(2) HCO data:

**BRAVO RANGE 6530, DEFLECTION 3310.**

(3) VCO data:

**AVERAGE SITE PLUS 2**

(4) Initial fire commands:

**RIGHT, THREE ROUNDS, IMMEDIATE SMOKE, CHARGE 4.**

By stating **IMMEDIATE SMOKE** in the initial fire commands, both guns in the right platoon know what shell/fuze combination they will fire as prescribed in the SOP. It is not necessary then to announce shell or fuze.

*d. Determination of Data (fig 11-18).*

(1) *Fuze setting.* Place the MHL of the GFT over the chart range 6530 and read an

M564 fuze setting of 25.7. Subtract 2.0 to determine the fuze setting to fire (23.7). This fuze setting is announced to both guns. No. 1 will not need the fuze setting for the first round he fires since it will be WP, fuze quick. However, both guns will fire smoke, fuze time on the subsequent volleys.

(2) *Deflection.* Apply the total df correction (L7) to the chart deflection (3310) to determine the deflection to fire (3317).

(3) *Quadrant elevation.* Place the MHL of the GFT on the chart range (6530) and read elevation 448 under the elevation gageline. Apply the average site (+2) to the elevation to determine the quadrant to fire 450 (448 + (+2)).

## 11-20. Manual Solution Using GFT (Quick Smoke)

For a quick smoke mission, the observer begins the adjustment with one piece firing shell HE, fuze quick. When the observer has adjusted the point of impact within 100 meters of the adjusting point, he calls for shell smoke to complete the adjustment. The adjustment is continued with smoke until the proper height of burst is obtained (approximately 100 meters). Then the observer calls for fire for effect to build and

maintain the smokescreen. (Quick smoke can also be fired with WP in effect.)

*a. Initial Preparation.* The FDC must determine the number of platoons required to fire the mission, the length of time and rate of fire of the mission, and how many rounds each gun must fire in effect. To determine this data, the FDC must have the following information from the FO's call for fire:

- (1) Width of target (in meters) to be obscured.
- (2) General wind direction (cross, head, or tail).
- (3) Duration of smoke (minutes).
- (4) Type of projectile desired in effect (smoke or WP).

*b. Determination of Number of Platoons to Fire for Effect.*

(1) Given the width of the target to be obscured, wind direction, and the shell to be fired in effect, enter table 11-8 for the proper weapon and ammunition.

(2) Extract from the bottom line (platoon to fire) the number of platoons needed to fire for effect. For example, for 155-mm firing shell smoke, headwind, target width 200 meters, the number of platoons to fire would be two platoons.

### RECORD OF FIRE

|                                       |  |                          |  |                       |  |                    |  |                   |  |
|---------------------------------------|--|--------------------------|--|-----------------------|--|--------------------|--|-------------------|--|
| Observer <u>PS1</u>                   |  | CALL FOR FIRE <u>IMM</u> |  | Tgt <u>SMK</u>        |  | AVG SITE <u>+2</u> |  | △ PS              |  |
| Grid: <u>625371</u>                   |  | AF/FFE/IS/S              |  |                       |  |                    |  | 100/R             |  |
| Polar: Dir _____                      |  | Dis _____                |  | U/D _____             |  | VA _____           |  | /R                |  |
| Shift _____                           |  | Dir _____                |  | L/R _____             |  | +/- _____          |  | 20/R              |  |
|                                       |  |                          |  |                       |  |                    |  | HOB Corr          |  |
| FIRE ORDER <u>IMM SMOKE RIGHT (3)</u> |  |                          |  |                       |  | Df Corr <u>L7</u>  |  | Si <u>+2</u>      |  |
| INITIAL FIRE COMMANDS                 |  | FM MF <u>RIGHT (3)</u>   |  | Rg <u>6530 (25.7)</u> |  | Chf Df <u>3310</u> |  | EI <u>448</u>     |  |
| Sp Instr <u>IMM SMOKE</u>             |  | Sh _____                 |  | Lot _____             |  | Chg <u>237</u>     |  | Df <u>3317</u>    |  |
| MTO                                   |  | X T                      |  | PEr                   |  | TF                 |  | in Eff            |  |
|                                       |  |                          |  |                       |  |                    |  | Ammo Exp <u>⑤</u> |  |
| Tgt                                   |  | Location                 |  | Priority              |  | Firing Unit        |  |                   |  |
|                                       |  |                          |  |                       |  |                    |  |                   |  |
| Dir, MF                               |  | Dev                      |  | Rg                    |  | HOB Corr           |  | MF, Sh, Chg, Fz   |  |
| Sh, Fz                                |  |                          |  |                       |  |                    |  | FS Corr           |  |
|                                       |  |                          |  |                       |  |                    |  | Ti                |  |
|                                       |  |                          |  |                       |  |                    |  | Chart Df          |  |
|                                       |  |                          |  |                       |  |                    |  | Df Corr ( )       |  |
|                                       |  |                          |  |                       |  |                    |  | Df Fired          |  |
|                                       |  |                          |  |                       |  |                    |  | Chart Rg          |  |
|                                       |  |                          |  |                       |  |                    |  | HOB Corr          |  |
|                                       |  |                          |  |                       |  |                    |  | Si ( )            |  |
|                                       |  |                          |  |                       |  |                    |  | EI                |  |
|                                       |  |                          |  |                       |  |                    |  | QE                |  |
|                                       |  |                          |  |                       |  |                    |  | Exp               |  |
|                                       |  |                          |  |                       |  |                    |  | Type              |  |

Figure 11-18. Manual solution using GFT (immediate smoke).



Table 11-8. Table of Quick Smoke Data

| Weapon/Ammo      |    | Width of Target to be Obscured in Meters |         |         |           |         |         |
|------------------|----|------------------------------------------|---------|---------|-----------|---------|---------|
|                  |    | Wind Direction                           |         |         |           |         |         |
|                  |    | Cross                                    |         |         | Head/Tail |         |         |
| 155mm            | HC | 400                                      | 500     | 600     | 100       | 200     | 300     |
|                  | WP | 200                                      | 300     | 400     | 100       | 200     | 300     |
| 105mm            | HC | 300                                      | 400     | 500     | 100       | 200     | 300     |
|                  | WP | 100                                      | 200     | 300     | 100       | 200     | 300     |
| Platoons to Fire |    | 1 Plt                                    | 2 Plt's | 3 Plt's | 1 Plt     | 2 Plt's | 3 Plt's |

*c. Determination of Rate of Fire.*

(1) Determine the total time during which smoke is to be replenished.

(a) The length of time the smoke is required is 9 minutes.

(b) Add the time to build an effective level (table 11-9). The sum is equal to the duration of smoke.

(c) Subtract from the duration of smoke the average burning time (table 11-9). The difference is the total time during which smoke is to be replenished.

|                                                       |             |
|-------------------------------------------------------|-------------|
| Length of time smoke required                         | 9 minutes   |
| Time to build to effective level<br>(table 11-9)      | + 1 minute  |
| Duration of smoke                                     | 10 minutes  |
| Average burning time<br>(table 11-9)                  | - 4 minutes |
| Total time during which smoke<br>is to be replenished | 6 minutes   |

Table 11-9. Smoke Round Effectiveness

|                   | 105mm |       | 155mm |       |
|-------------------|-------|-------|-------|-------|
|                   | HC    | WP    | HC    | WP    |
| Time for Buildup  | 1 min | ½ min | 1 min | ½ min |
| Average Burn Time | 3 min | 1 min | 4 min | 1 min |

(2) Determine the weather condition (ideal, favorable, or marginal) and the windspeed.

(a) The weather conditions, the time of day, and the windspeed all affect atmospheric stability. The atmospheric stability is categorized into three temperature gradients—inversion (stable), neutral, and lapse (unstable). The temperature gradient is an expression of the difference in air temperature from ½ meter to 4 meters above the ground. Vertical variations in temperature affect air stability, which in turn affects the formation of vertical air currents. The weather condition can be determined from table 11-10.

(b) The windspeed is also very important, since it will determine how fast the smoke will move after it is on the ground. The FDC may determine the windspeed from line 00 of a current met message or from an equivalent wind scale table (table 11-11).

Table 11-10. General Atmospheric Conditions and Effect on Smoke

### GENERAL ATMOSPHERIC CONDITIONS AND EFFECT ON SMOKE

| TEMPERATURE GRADIENT | WEATHER CONDITION | Time of Day or Weather Conditions                                                                                                                                                         | Expected Smoke Behavior as the Smoke Drifts Downwind (Wind Direction → → →)                                                                 |
|----------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| INVERSION            | IDEAL             | 1. NIGHT – until 1 hour after sunrise.<br>2. Wind speed less than 5 knots.<br>3. Sky cover less than 30 percent.<br><b>ALL THREE CONDITIONS MUST BE MET.</b>                              | <br>Stable condition – Ideal for smoke employment.      |
| NEUTRAL              | FAVORABLE         | Not Ideal or Marginal. This condition will occur most often 1-2 hours before and after sunrise and whenever the wind speed is 5 knots or more and/or the sky cover is 30 percent or more. | <br>Neutral condition – Favorable for smoke employment. |
| LAPSE                | MARGINAL          | 1. DAY – beginning 2 hours after sunrise.<br>2. Wind speed less than 5 knots.<br>3. Sky cover less than 30 percent.<br><b>ALL THREE CONDITIONS MUST BE MET.</b>                           | <br>Unstable condition – Marginal for smoke employment. |

Table 11-11. Equivalent Wind Scale Table

| KNOTS | OBSERVATION                                                                                                                                    |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Smoke, vapor from breath, or dust raised by vehicles or personnel rises vertically/no leaf movement.                                           |
| 1-3   | Direction of wind slightly shown by smoke, vapor from breath, or dust raised by vehicles or personnel. Slight intermittent movement of leaves. |
| 4-6   | Wind slightly felt on face/leaves rustle.                                                                                                      |
| 7-10  | Leaves and small twigs in constant motion.                                                                                                     |
| 11-16 | Wind raises dust from ground/loose paper and small branches move.                                                                              |
| 17-21 | Small trees with leaves sway/coastal wavelets form on inland waters.                                                                           |
| 22-27 | Large branches on trees in motion/whistle heard in telephone or fence wires.                                                                   |
| 28-33 | Whole trees in motion/inconvenience felt walking against wind.                                                                                 |

(3) To determine the rate of fire, enter table 11-12 with the weather condition, windspeed, and appropriate weapon/shell. For example:

(a) Enter table 11-12 with the weather condition of favorable and windspeed of 5 knots.

(b) Extract the rate of fire of one-half round per minute per gun (1 round every 2 minutes) under the column for 155-mm smoke.

*d. Calculation of Total Number of Rounds Per Gun.*

(1) Determine the number of sustaining rounds required per gun by multiplying the rate of fire by the duration of replenishment ( $\frac{1}{2} \times 6 = 3$  rounds).

Table 11-12. Rate of Fire Table

| WEATHER CONDITIONS | WIND SPEED IN KNOTS | ROUNDS PER MINUTE |    |       |    |
|--------------------|---------------------|-------------------|----|-------|----|
|                    |                     | 105mm             |    | 155mm |    |
|                    |                     | HC                | WP | HC    | WP |
| Ideal              | 5                   | 1                 | 1½ | ½     | ½  |
| Favorable          | 5                   | 1                 | 2  | ½     | 1  |
|                    | 10                  | 2                 | 4  | 1     | 2  |
|                    | 15                  | 2½                | 6  | 1½    | 3  |
| Marginal           | 5                   | 3                 | *  | 1½    | *  |

\* Under these conditions, the number of rounds exceeds the rate of fire for the weapon.

(2) Add the initial fire for effect smoke round to the sustaining rounds ( $1 + 3 = 4$  rounds). Therefore, each piece will fire one round of smoke initially in fire for effect and one round every 2 minutes for the next 6 minutes to provide effective smoke for 10 minutes. If the calculation in d(1) above results in partial rounds; e.g.,  $4\frac{1}{2}$ , then the rounds must be expressed up to the next whole number and then the initial round added. Example:  $4\frac{1}{2} \approx 5 + 1 = \textcircled{6}$ .

*e. Execution.*

(1) Prior to issuing the fire order and announcing fire commands to the guns, choose the centermost gun of the fire for effect platoons as the adjusting piece.

(2) Since the computation for the number of rounds per piece and the rate of fire are accomplished while the adjustment is being conducted, number of rounds to fire in effect will not be announced initially, but will be announced as soon as calculated. The FDC will control the time of firing of the smoke rounds since a specific rate of fire is required.

*f. Determination of Firing Data.*

(1) The mission is performed in two phases. The first phase is the adjustment of shell HE, fuze quick. The second phase is the adjustment and fire for effect with shell

smoke with time fuze M501A1. The FDC procedures discussed here are only for shell smoke.

(2) The adjustment with smoke begins when the observer calls for smoke and continues until he obtains the proper effect to include the correct height of burst. Firing data is determined as follows:

(a) *Chart data.* The observer's last corrections are plotted and chart range and deflection determined.

(b) *Fuze setting.* Place the MHL of the GFT over the chart range and read the M564 fuze setting under the time gageline. Subtract 2.0 from the fuze setting and announce the fuze setting to fire. The decrease in fuze setting causes the correct HOB with the M501A1 fuze. This correction is made each time a fuze setting is read when firing shell smoke.

(c) *Deflection.* Apply the deflection correction (GFT DF CORR + DRIFT) that was used in the adjustment with shell HE to the chart deflection to determine the deflection to fire.

(d) *Quadrant elevation.* Place the MHL of the GFT over the chart range and read the elevation under the elevation gageline. Apply the site (initial site determined at the beginning of the mission) and announce as the quadrant to fire. Do not apply 20/R. Base ejection white smoke normally is the same weight as HE; therefore, a weight correction is not required. However, base ejection colored smoke is considerably lighter than HE and the accuracy of colored smoke can be improved by applying a weight correction.

(e) *Height-of-burst corrections.* When the observer sends a correction to the height of burst, the FDC makes a correction by changing the total site. This is done by applying the value of 50/R (determined at the initial chart range of the mission) for each 50-meter increment in the correction.

*Example:*

|                |           |
|----------------|-----------|
| Correction     | UP 50     |
| 100/R          | 20        |
| Old Site       | +7        |
| 50/R           | <u>10</u> |
| New Total Site | +17       |

To correct the height of burst, change only the total site; do not correct the fuze setting.

*Example (Quick Smoke):*

The following problem illustrates the procedure for firing quick smoke. Although the M116B1 (smoke) projectile and HE107 scales prepared for the M109A1 howitzer are used in the example, these procedures are applicable for all weapons firing smoke.

*a. Known Data For an M109A1 Howitzer.*

GFT B: Chg 4, Lot XY, Rg 6080, El 402, Ti 23.3

GFT df corr: R2

Lot Y is Green Bag.

Lot T is shell M116B1, smoke.

*b. Situation.* The following call for fire has been received in the FDC:

**P51 THIS IS P28, ADJUST FIRE, OVER.**

**GRID 627 364, OVER.**

**SCREEN TREELINE, 500 METERS, CROSSWIND, DURATION 10 MINUTES, SMOKE IN EFFECT.**

*c. Situation Continued.*

(1) Before the FDO can issue a fire order, the number of platoons to fire must first be determined. Entering table 11-8 with 155-mm smoke, crosswind, and a target width of 500 meters, the number of platoons to fire is determined to be two.

(2) Fire order:

**RIGHT AND CENTER, SHELL SMOKE, LOT TANGO YANKEE, FUZE TIME IN EFFECT.**

The number of rounds to fire in effect has not been determined at this time; therefore, it is omitted from the fire order. The number of rounds to fire will be announced later in the mission. Also, no adjusting piece had to be stated in the fire order because No. 3 is the standard adjusting piece and No. 3 is near the center of the right and center platoons.

(3) HCO data:

BRAVO RANGE 5470, DEFLECTION 3172.

(4) VCO data:

BRAVO SITE MINUS 3.

(5) Initial fire commands:

RIGHT AND CENTER ADJUST,  
CHARGE 4, DEFLECTION 3177,  
QUADRANT 344, SHELL SMOKE.  
LOT TANGO YANKEE, FUZE TIME  
IN EFFECT.

The first round fired in adjustment is HE/Q and data is computed in the normal manner.

*d. Determination of Number of Rounds to Fire in Effect.* While the adjustment is in progress, the remaining critical information for the fire for effect phase is determined.

(1) The total time during which smoke is to be replenished is as follows (see table 11-9):

|                                                    |                |
|----------------------------------------------------|----------------|
| Length of time smoke is required                   | 10 min         |
| Time to build to effect level                      | <u>+ 1 min</u> |
| Duration of smoke                                  | 11 min         |
| Average burning time                               | <u>- 4 min</u> |
| Total time during which smoke is to be replenished | 7 min          |

(2) The weather condition is determined to be favorable and the windspeed to be 5 knots.

(3) Entering table 11-12 with the weather condition and windspeed, a rate of fire of one-half round per minute (one round every 2 minutes) is extracted.

(4) The total number of rounds per piece is then determined.

$$\frac{1}{2} \times 7 = 3\frac{1}{2} \quad 4$$

$$4 + 1 \text{ (initial round)} = 5 \text{ rounds per tube.}$$

*e. Determination of Smoke Data.*

(1) Further into the mission, the following corrections are received:

**SMOKE ADD 100**

(2) The fire commands to the guns are now changed:

SHELL SMOKE, LOT TANGO  
YANKEE, FUZE TIME.

*Note.* The mission is currently still in the adjustment phase, but with shell smoke.

(3) HCO data:

BRAVO RANGE 5360, DEFLECTION 3174.

(4) Firing data:

(a) *Fuze setting.* Place the MHL over range 5360, and determine the M564 fuze setting to be 19.8. Subtract 2.0 to determine the fuze setting to fire (17.8).

(b) *Deflection.* Apply the deflection correction that was used in the adjustment with shell HE (L5) to the chart deflection (3174) to determine the deflection to fire (3179).

(c) *Quadrant elevation.* Place the MHL over the chart range (5360) and determine the elevation (337). Apply site -3 mils to determine the quadrant to fire (334).

*f. Situation Continued (FFE, HOB Correction).*

(1) The observer watches the initial smoke round and sends his next correction.

**UP 50, FFE**

(2) Having changed to FFE, the next commands are sent to the guns.

**RIGHT AND CENTER, 5 ROUNDS,  
BY ROUND, AT MY COMMAND.**

(3) Firing data are determined as follows:

(a) Since no deviation or range correction was given, the chart range and deflection remains the same; therefore, the fuze setting, deflection, and elevation to fire remain the same. If there had been a deviation and/or range change given, new chart range and deflection would have been determined. A new fuze setting, deflection, and elevation would have been determined corresponding to the new chart data.

(b) The quadrant must be corrected by a 50-meter increase in HOB. Using 50/R (determined from 100/R at the initial chart range of the mission), the quadrant is determined as follows:

|                       |     |
|-----------------------|-----|
| HOB correction (50/R) | +10 |
| + old site            | -3  |
| new total site        | +7  |
| + el                  | 337 |
| quadrant              | 344 |

(4) The rounds would be fired at the correct rate of fire, in this case one round per gun, one volley every 2 minutes.

#### 11-21. FADAC Procedures

*a. Immediate Smoke.* Data is computed for an immediate smoke mission by

determining shell HE/fuze quick data. The deflection and quadrant are fired for both WP and smoke. The time setting for the smoke rounds is determined by subtracting 2.0 from the displayed time of flight.

*b. Quick Smoke.* Data is quickly and accurately computed for a quick smoke mission by simply overriding the appropriate shell and fuze. For 155-mm, FADAC stores the standard weight for the colored smoke round (86.4 pounds). This weight must be corrected to 95.0 pounds when entering known data.

#### 11-22. Reference Tables for Quick Smoke

*a.* Even under the best conditions, computing for the number of rounds required in a quick smoke mission is time consuming.

*b.* Given below are quick reference tables which allow the computer to determine the number of fire for effect rounds per tube for the 105-mm and 155-mm howitzers with shells smoke and WP. Determination of the number of platoons in FFE is the same as in paragraph 11-20*b*.

Table 11-8. Quick Smoke—155-mm—SH SMK.

| FIRE FOR EFFECT—ROUNDS PER TUBE |                    |              |                                    |   |   |   |   |    |    |    |    |    |    |    |
|---------------------------------|--------------------|--------------|------------------------------------|---|---|---|---|----|----|----|----|----|----|----|
| Weather Condition               | Wind speed (knots) | Rate of Fire | Duration requested by FO (minutes) |   |   |   |   |    |    |    |    |    |    |    |
|                                 |                    |              | 4                                  | 5 | 6 | 7 | 8 | 9  | 10 | 11 | 12 | 13 | 14 | 15 |
| Ideal                           | 5                  | 1 RD/2 min   | 2                                  | 2 | 3 | 3 | 4 | 4  | 5  | 5  | 6  | 6  | 7  | 7  |
| Favorable                       | 5                  | 1 RD/2 min   | 2                                  | 2 | 3 | 3 | 4 | 4  | 5  | 5  | 6  | 6  | 7  | 7  |
|                                 | 10                 | 1 RD/1 min   | 2                                  | 3 | 4 | 5 | 6 | 7  | 8  | 9  | 10 | 11 | 12 | 13 |
|                                 | 15                 | 1 RD/40 sec  | 3                                  | 4 | 6 | 7 | 9 | 10 | 12 | 13 | 15 | 16 | 18 | 19 |
| Marginal                        | 5                  | 1 RD/40 sec  | 3                                  | 4 | 6 | 7 | 9 | 10 | 12 | 13 | 15 | 16 | 18 | 19 |

Table 11-9. Quick Smoke—155-mm—SH WP.

| FIRE FOR EFFECT—ROUNDS PER TUBE |                    |                      |                                    |    |    |    |    |    |    |    |    |    |    |    |
|---------------------------------|--------------------|----------------------|------------------------------------|----|----|----|----|----|----|----|----|----|----|----|
| Weather Condition               | Wind speed (knots) | Rate of Fire         | Duration requested by FO (minutes) |    |    |    |    |    |    |    |    |    |    |    |
|                                 |                    |                      | 4                                  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 |
| Ideal                           | 5                  | 1 RD/2 min           | 3                                  | 4  | 4  | 5  | 5  | 6  | 6  | 7  | 7  | 8  | 8  | 9  |
| Favorable                       | 5                  | 1 RD/min             | 5                                  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|                                 | 10                 | 1 RD/30 sec          | 8                                  | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |
|                                 | 15                 | 1 RD/20 sec          | 12                                 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 |
| Marginal                        | 5                  | EXCEEDS RATE OF FIRE |                                    |    |    |    |    |    |    |    |    |    |    |    |

## Section V. CHEMICAL PROJECTILES

### 11-23. Characteristics and Employment

*a.* Chemical projectiles for cannon artillery consist of HC smoke projectiles, white phosphorus projectiles, and gas projectiles. HC smoke and white phosphorus have been discussed previously. This section will pertain to the gas projectiles. Chemical agents may be used to kill, injure, or harass personnel. The gas projectile is a burster-type projectile that is fired with either an impact or proximity fuze, depending on the type of filler. Gases available are irritant agents and lethal agents.

*b.* Toxic chemical agents are employed in either a vapor (nonpersistent-GB) form or a liquid droplet (persistent-VX) form. A different fire direction technique is required for achieving the best results with each form.

(1) When a chemical projectile is used for producing a nonpersistent vapor hazard in the target area:

(a) A point-detonating fuze normally should be used.

(b) Surprise fire is essential. Sufficient artillery must be used so that all rounds impact within 30 seconds.

(c) A separate point of impact is assigned to each battery-size unit.

(2) When a chemical projectile is used for contaminating the target area with persistent liquid droplets:

(a) A low airburst normally should be used.

(b) Surprise fire is not essential.

(c) Each group of rounds is fired at a different point of impact. Normally, zone fire will give the best coverage. If friendly troops are downwind from the target area, they must mask. See FM 3-10 for information concerning the computation of safety distance.

### 11-24. Manual Solution Using GFT and TFT

The manual solution incorporates the use of the GFT and the TFT to determine firing data for the weight correction of the chemical

projectiles. The TFT solution provides corrections to the range to compensate for the weight difference. When fire for effect is to be fired with a chemical projectile, the adjustment phase is normally conducted with HE, fuze quick. Data is determined as follows:

a. *Chart Data.* Chart range, deflection, and site are determined in the normal manner.

b. *Determination of Corrected Range.*

(1) Determine the difference in the weights (squares) of the projectiles by subtracting the weight of the HE from the weight of the chemical projectile. This correction is considered a constant and is not changed during any subsequent adjustment.

(2) From table F (fig 11-19), determine the correction for an increase in projectile weight of one square. Use initial chart range expressed to the nearest 100 meters for entry into table F.

(3) Determine the correction by multiplying the difference in projectile weight ((1) above) by the unit correction ((2) above).

(4) Apply the correction expressed to the nearest 10 meters to the fire for effect chart range. The result is the corrected range.

c. *Fuze Setting.* When employing a persistent liquid droplet agent (VX), a proximity fuze will usually be used. To determine the fuze setting, place the MHL over the corrected range and read the fuze setting on the M564 fuze scale from a line parallel to the MHL passing through the elevation determined with the elevation gageline. Express the value down to a whole increment; e.g., fuze setting determined  $23.7 \approx 23.0$ . If a nonpersistent agent (GB) is fired, a PD fuze will be used.

d. *Deflection.* The piece deflection determined for the chemical projectile is the same as that determined for HE. During an adjust fire mission (HE in adjustment chemical in effect), the deflection correction is determined and applied as usual; i.e., drift is determined corresponding to the initial HE

FT 155-AM-1

PROJ: HE, M107  
FUZE: PD, M557TABLE F  
CORRECTION FACTORSCHARGE  
4G

| 1                     | 10                          | 11    | 12                      | 13   | 14                   | 15   | 16                      | 17  | 18                               | 19  |
|-----------------------|-----------------------------|-------|-------------------------|------|----------------------|------|-------------------------|-----|----------------------------------|-----|
| R<br>A<br>N<br>G<br>E | RANGE CORRECTIONS FOR       |       |                         |      |                      |      |                         |     |                                  |     |
|                       | MUZZLE<br>VELOCITY<br>1 M/S |       | RANGE<br>WIND<br>1 KNOT |      | AIR<br>TEMP<br>1 PCT |      | AIR<br>DENSITY<br>1 PCT |     | PROJ WT<br>OF 1 SQ<br>(4 SQ STD) |     |
|                       | DEC                         | INC   | HEAD                    | TAIL | DEC                  | INC  | DEC                     | INC | DEC                              | INC |
|                       | M                           | M     | M                       | M    | M                    | M    | M                       | M   | M                                | M   |
| 3500                  | 19.8                        | -15.2 | 4.4                     | -1.1 | 9.3                  | -1.5 | -2.8                    | 2.9 | -26                              | 28  |
| 3600                  | 20.3                        | -15.6 | 4.6                     | -1.2 | 9.5                  | -1.5 | -3.0                    | 3.0 | -26                              | 29  |
| 3700                  | 20.8                        | -16.0 | 4.7                     | -1.2 | 9.8                  | -1.5 | -3.2                    | 3.2 | -27                              | 29  |
| 3800                  | 21.4                        | -16.4 | 4.9                     | -1.3 | 10.0                 | -1.6 | -3.3                    | 3.4 | -28                              | 30  |
| 3900                  | 21.9                        | -16.8 | 5.0                     | -1.3 | 10.2                 | -1.6 | -3.5                    | 3.5 | -28                              | 31  |
| 4000                  | 22.4                        | -17.2 | 5.1                     | -1.4 | 10.5                 | -1.6 | -3.7                    | 3.7 | -29                              | 31  |
| 4100                  | 22.9                        | -17.6 | 5.3                     | -1.5 | 10.7                 | -1.7 | -3.8                    | 3.9 | -29                              | 32  |
| 4200                  | 23.4                        | -18.0 | 5.4                     | -1.5 | 10.9                 | -1.7 | -4.0                    | 4.1 | -30                              | 33  |
| 4300                  | 23.9                        | -18.4 | 5.6                     | -1.6 | 11.1                 | -1.7 | -4.2                    | 4.3 | -30                              | 33  |
| 4400                  | 24.4                        | -18.8 | 5.7                     | -1.6 | 11.3                 | -1.8 | -4.4                    | 4.5 | -31                              | 34  |
| 4500                  | 24.9                        | -19.2 | 5.9                     | -1.7 | 11.5                 | -1.8 | -4.6                    | 4.7 | -31                              | 34  |
| 4600                  | 25.4                        | -19.6 | 6.0                     | -1.8 | 11.7                 | -1.8 | -4.8                    | 4.9 | -32                              | 35  |
| 4700                  | 26.0                        | -20.0 | 6.1                     | -1.8 | 11.9                 | -1.8 | -5.0                    | 5.1 | -32                              | 36  |
| 4800                  | 26.5                        | -20.4 | 6.3                     | -1.9 | 12.0                 | -1.9 | -5.2                    | 5.3 | -33                              | 36  |
| 4900                  | 27.0                        | -20.8 | 6.4                     | -2.0 | 12.2                 | -1.9 | -5.4                    | 5.5 | -33                              | 37  |
| 5000                  | 27.5                        | -21.2 | 6.5                     | -2.0 | 12.4                 | -1.9 | -5.6                    | 5.7 | -34                              | 37  |
| 5100                  | 28.0                        | -21.6 | 6.7                     | -2.1 | 12.5                 | -1.9 | -5.8                    | 5.9 | -35                              | 38  |
| 5200                  | 28.5                        | -22.0 | 6.8                     | -2.2 | 12.7                 | -1.9 | -6.1                    | 6.2 | -35                              | 38  |
| 5300                  | 29.0                        | -22.4 | 6.9                     | -2.2 | 12.9                 | -2.0 | -6.3                    | 6.4 | -36                              | 39  |
| 5400                  | 29.4                        | -22.8 | 7.1                     | -2.3 | 13.0                 | -2.0 | -6.5                    | 6.6 | -36                              | 39  |
| 5500                  | 29.9                        | -23.2 | 7.2                     | -2.4 | 13.2                 | -2.0 | -6.8                    | 6.9 | -36                              | 40  |
| 5600                  | 30.4                        | -23.6 | 7.3                     | -2.5 | 13.3                 | -2.0 | -7.0                    | 7.1 | -37                              | 41  |
| 5700                  | 30.9                        | -24.1 | 7.4                     | -2.5 | 13.4                 | -2.0 | -7.2                    | 7.4 | -37                              | 41  |
| 5800                  | 31.4                        | -24.5 | 7.6                     | -2.6 | 13.6                 | -2.0 | -7.5                    | 7.6 | -38                              | 42  |
| 5900                  | 31.9                        | -24.9 | 7.7                     | -2.7 | 13.7                 | -2.1 | -7.7                    | 7.9 | -38                              | 42  |

Figure 11-19. Determination of corrected range.

elevation and applied to the GFT deflection correction. The resulting deflection correction does not change throughout the mission. In a fire for effect mission with shell chemical, the drift will be determined after the weight correction has been computed and applied. Drift, then, will be determined corresponding to the chemical elevation and applied to the GFT deflection correction in the normal manner.

e. *Quadrant Elevation.* Place the MHL of the GFT over the corrected range and read the elevation under the elevation gageline. Apply site to the elevation to determine quadrant elevation.

#### Example (GFT/TFT Fire for Effect):

The following problem illustrates the procedures for firing chemical projectiles. Although the M121A1 projectile, GFT HE107 scales, and FT 155-AM-1 prepared for the M109A1 howitzer are used in this example, these procedures are applicable for all weapons firing chemical projectiles.

*a. Known Data for M109A1 Howitzer.*

GFT: GFT B: Chg 4, Lot XY, Rg 6080, El 402, Ti 23.3

GFT df corr: R2

Lot Y is Green Bag.

Lot P is shell chemical, GB, M121A1.

Chemical (GB) weight: 7 ☐

HE weight: 4 ☐

*b. Situation.*

The following call for fire has been received in the FDC:

**P28 THIS IS P29, FIRE FOR EFFECT, OVER.**

**GRID 621 375, OVER.**

**PLATOON DUG IN, CHEMICAL, GB, OVER.**

*c. Situation Continued.**(1) Fire order:*

**FIRE FOR EFFECT, SHELL CHEMICAL, GB, LOT PAPA YANKEE, THREE ROUNDS.**

*(2) HCO data:*

**BRAVO RANGE 5780, DEFLECTION 3196.**

*(3) VCO data:*

**SITE BRAVO MINUS 2.**

*(4) Initial fire commands:*

**BATTERY THREE ROUNDS, SHELL CHEMICAL, GB, LOT PAPA YANKEE, CHARGE 4.**

*d. Determination of Corrected Range.*

*(1) The difference in weight is 3 squares.*

|               |                             |
|---------------|-----------------------------|
| Chemical (GB) | 7 <input type="checkbox"/>  |
| - HE          | 4 <input type="checkbox"/>  |
| Wt            | +3 <input type="checkbox"/> |

*(2) From table F (fig 11-19), charge 4GB, enter with initial chart range expressed to the nearest 100 meters (5780  $\approx$  5800). Comp range is not considered. Extract from the column headed "Proj Wt of 1 SQ, INC," the value of +42.*

*(3) Multiply the difference in weight (3 squares) by the unit correction (+42) and express to the nearest 10 meters.*

$$+42 \times 3 = +126 \approx +130$$

*(4) Apply the correction (+130 meters) to the fire for effect chart range (5780) to determine the corrected range.*

$$5780 + 130 = 5910$$

*e. Determination of Firing Data.*

*(1) Fuze setting.* Shell chemical, GB, is fired with fuze quick.

*(2) Deflection.* The piece deflection fired is the chart deflection 3196 + the GFT DF correction (R2) + drift (L8) = Deflection 3202. The drift was determined at the elevation corresponding to the corrected range.

*(3) Quadrant elevation.* Place the MHL of the GFT over the corrected range (5910) and read the elevation under the elevation gageline (385). Apply the site (-2) to determine the quadrant to fire (383).

**11-25. FADAC Procedures**

*a.* Chemical missions can be computed quickly and accurately with FADAC by simply designating the correct projectile and fuze to fire.

*b.* FADAC will automatically compute and apply the range correction for the weight difference between the chemical round and HE.



# CHAPTER 12

## FIRE DIRECTION PROCEDURES FOR SPECIAL SITUATIONS

### Section I. DEDICATED BATTERY OPERATIONS

#### 12-1. Dedicated Battery Mission

- ★ a. The dedicated battery is a battery whose total firepower is immediately available to support a designated maneuver company or team. The dedicated battery has direct fire planning and communication channels with the company/team (fig 12-1). The dedicated battery uses preplanned firing data and abbreviated procedures to answer calls for fire responsively. For information on the tactics and techniques of employment of the dedicated battery, refer to FM 6-20 and FM 6-20-1, *Field Artillery Cannon Battalion*.

b. Normally, the dedicated battery is required to provide suppressive fires. There are two categories of suppressive fires: planned and immediate.

(1) Planned suppressive fires are on call and located on easily identifiable points from which the observer and maneuver personnel can shift rapidly to targets of opportunity. The observer calls for suppressive fires when the maneuver element is exposed to a suspect enemy location.

(2) Immediate suppressive fires are required when the enemy actually is firing at

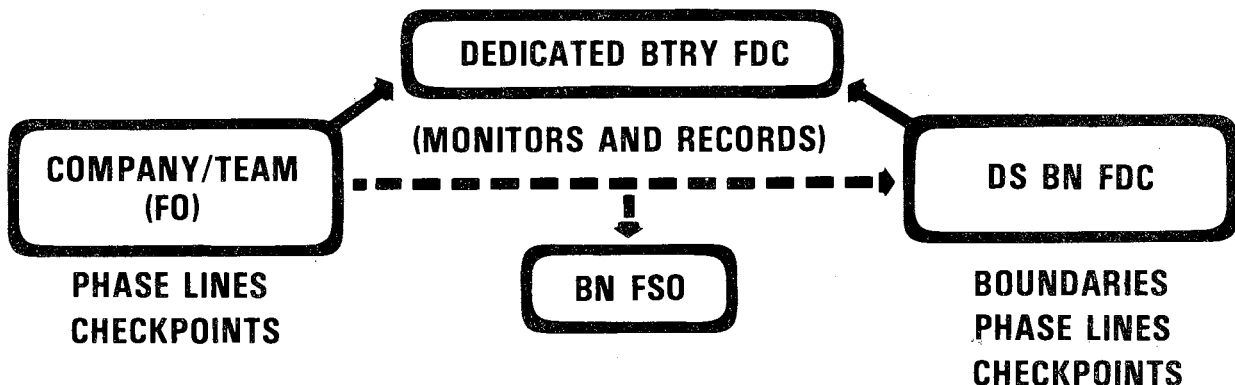


Figure 12-1. Fire planning and communication channels.

friendly maneuver elements with direct fire weapons. In immediate suppression, short reaction time by the artillery is more important than pinpoint accuracy. A call for immediate suppressive fires means the observer needed fire 10 seconds ago.

## 12-2. Preparation for the Dedicated Battery Role

When assigned the role of dedicated battery, FDC personnel must begin intensive preparations immediately. They must obtain and become familiar with the company/team scheme of maneuver and all control measures. FDC personnel must understand completely the scheme of maneuver and maneuver control measures, the plan of fire support, call signs and frequencies, the processing of planned targets, and the proper use of the SOP fire order and fire commands to increase responsiveness.

*a. The Scheme of Maneuver and Control Measures.* Dedicated battery FDC personnel must insure that the maneuver unit's control measures (line of departure, checkpoints, phase lines, boundaries, objectives) are

immediately available within the FDC. Control measures should be posted on firing charts and the situation map. All checkpoints should be plotted accurately in blue.

*b. The Plan of Fire Support.* The plan of fire support, which is prepared by the FIST chief, designates all preplanned fires that the dedicated battery must be prepared to engage quickly. The plan is transmitted to the FDC by one of two means: deliberate fire planning channels (from FIST to battalion FSO to battalion FDC to dedicated battery) or hasty fire planning channels (by radio from FIST to battery FDC). The plan of fire support designates target locations, methods of engagement, and priorities of fire. Targets and checkpoints are named by a simple and standardized numbering system.

c. *Call Signs and Frequencies.* Maneuver company and FIST call signs are recorded directly on the firing chart for ready reference. Frequencies are allocated in advance and planned to facilitate operations. Battery FDC personnel will monitor the maneuver company/team net (fig 12-2).

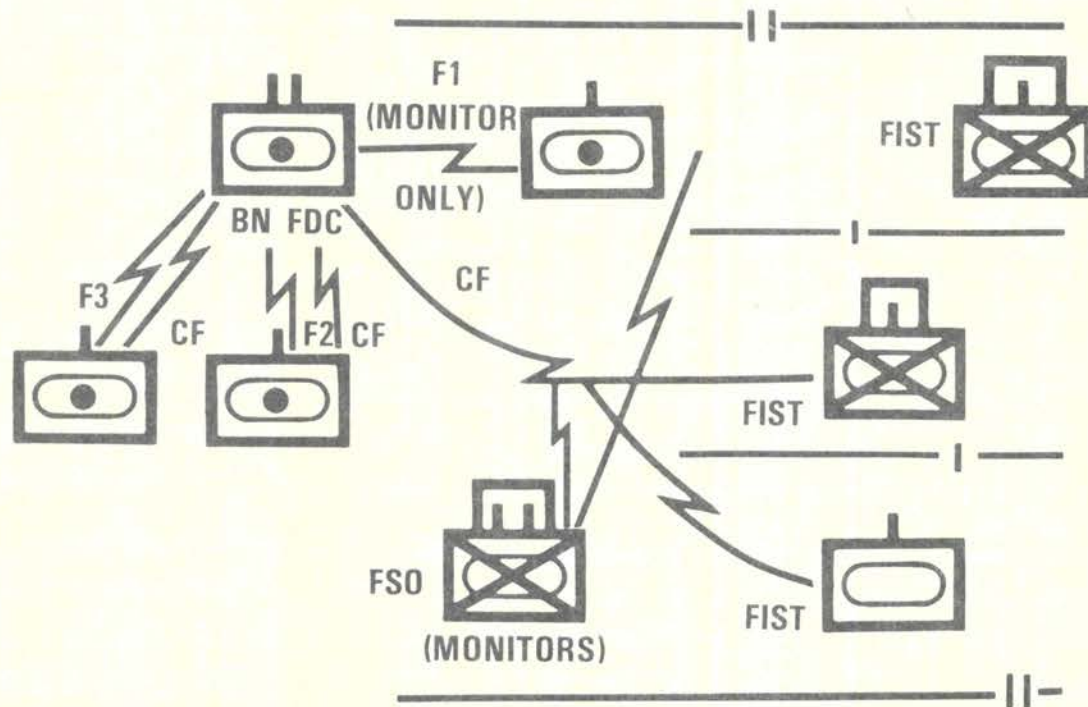


Figure 12-2. Communication channels.

d. *Processing the Planned Targets.* Dedicated battery FDC personnel plot and compute firing data for all planned targets and checkpoints. Priority targets should be assigned on the basis of one per platoon. Data for other suppressive targets is sent to all howitzer sections. The battery FDO decides which platoons lay on which targets, based on priorities established by the maneuver company/team commander and the FIST chief. To assist in identifying platoon assignments, the top left quadrant of each tickmark is used to indicate the platoon to which that target is assigned.

e. *Use of SOP, Fire Order, and Fire Commands.*

(1) A good SOP will aid in streamlining procedures to gain responsiveness. SOP items should include amount and type of ammunition for suppression and immediate smoke missions, guidance on the use of minimum safe time for variable time (VT)

fuze, prearranged fire orders and fire commands and their use, howitzer section responsibilities for priority targets and preparation of ammunition, and other procedures for accomplishing various tasks.

(2) The fire order and fire commands standards should be selected on the basis of responsiveness to expedite support of the maneuver company or team. Table 12-1 shows the considerations for each element of the fire order and a recommended standard.

(3) The command to fire on a preplanned target consists of two elements: pieces to fire/method of fire and target number.

RIGHT  
SUPPRESS 46

As the firing data for suppression of a preplanned target is already at the guns, only a cursory command to fire is necessary. SOP fire commands will enhance responsiveness.

Table 12-1. Considerations for Each Element of the Fire Order

| Element                                    | Considerations                                                                                                     | Standard                                                     |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| Unit to fire                               | Firing by platoon allows handling of multiple missions and provides for three priority targets.                    | Platoon<br>(left, center, or right designated in fire order) |
| Adj element/method of fire of adj element  | Suppression missions are FFE missions.                                                                             | FFE                                                          |
| Basis for corrections                      | 1. Planned targets: precomputed data.<br>2. Unplanned targets: fastest method (GFT fan).                           | Fastest method                                               |
| Distribution                               | Special sheafs are not time responsive. Use TGPC if necessary.                                                     | Primary                                                      |
| Projectile                                 | Established by SOP.                                                                                                | HE                                                           |
| Ammunition lot and charge                  | Accuracy, use large lot that has been registered.<br>Responsiveness, use higher charge to decrease time of flight. | XY, 5                                                        |
| Fuze                                       | Established by SOP, airburst normally better for suppression.                                                      | VT                                                           |
| Number of rounds                           | Established by SOP.                                                                                                | ②                                                            |
| RG spread, lateral spread, sweep, or zone. | Maintain responsiveness and simplicity.                                                                            | Center rg and df                                             |
| Time of opening fire                       | Responsiveness.                                                                                                    | When ready                                                   |

## 12-3. Mission Processing

*a. Firing Data for Planned Targets.* The method of computing firing data for planned targets depends on the amount of time available before the maneuver operation begins. Time permitting, the data is computed and doublechecked using FADAC and standard FDC procedures. If time is limited, the data is computed using streamlined procedures; later, as time permits, the data is updated with increasing accuracy. (See table 12-2.)

Regardless of the method of computing firing data, firing data is sent to the guns immediately. In requesting suppression of a preplanned target, the observer sends a simplified call for fire:

OBSERVER  
IDENTIFICATION THIS IS L24  
+  
WARNING ORDER SUPPRESS  
+  
TARGET LOCATION 46, OVER.

*b. Firing Data for Targets of Opportunity (Immediate Suppression).* Immediate suppression missions require even greater responsiveness from the battery FDC. On immediate suppression missions, the emphasis is on greater speed with a tradeoff of accuracy; a round close to the target now may be more effective than a round closer to the target 30 seconds later. Suppression is employed to restrict observation and degrade the fires of the enemy—not to neutralize him.

Table 12-2. Streamlined FDC Procedures for Suppression Missions

| Computing Firing Data Manually<br>(FADAC not available) |            |                                           |                                            |                   |                                                                                                  |
|---------------------------------------------------------|------------|-------------------------------------------|--------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------|
|                                                         | Chart Data | Basic Data                                | Corrections                                | Firing Data       |                                                                                                  |
| Unlimited Time                                          | Rg and df  | FS, df, and el                            | Df corr<br>Si<br>20/R (if applicable)      | FS:<br>df:<br>QE: | Read from appropriate gageline<br>Chart df and df corr<br>El + si + 20/R (if applicable)         |
| Minimum time                                            | *Rg and df | FS, df, and el or chart data from GFT fan |                                            | FS:<br>df:<br>QE: | Minimum safe time or GFT fan/chart data<br>Chart df and tot df corr<br>El + avg si (if computed) |
| First update                                            |            | Unchanged Same                            | Df corr average si<br>20/R (if applicable) | FS:<br>df:<br>QE: | Read from appropriate gageline<br>Chart df and df corr<br>El + avg si + 20/R (if applicable)     |
| Second update                                           |            | Unchanged Same                            | Actual ground si                           | FS:<br>DF:<br>QE: | Same<br>Same<br>El + tot si<br>(Tot si = 20/R + actual ground si)                                |

\*If the GFT fan is used, the chart data will be df, el, and FS.

The observer has two means by which he can locate the target of opportunity for immediate suppression.

(1) *Shift from a preplanned target or checkpoint.* The observer may choose to shift from a preplanned target or checkpoint. If he does so, he usually shifts along one of the eight cardinal directions (N, S, E, W, NE, NW, SE, SW).

**THIS IS Y69, IMMEDIATE SUPPRESSION, 800 METERS NORTH OF 15, OVER.**

The chart operator must immediately convert the direction to mils and plot the shift accordingly (fig 12-3). With training and experience, he can use a coordinate scale simply and quickly to "eyeball" the direction and plot the shift. Using the RDP or GFT fan, the chart operator announces chart data or firing data, as appropriate. The chart

operator then refines his plot of the target and orients his target grid in anticipation of subsequent observer corrections. The FDO considers the current tactical situation and the priority target assignments to determine which platoon would be most responsive to fire and issues an abbreviated fire order accordingly: **RIGHT PLATOON.** If suppression fire command standards are in effect, abbreviated fire commands are sent to the guns: **FIRE MISSION, RIGHT, 2 ROUNDS, DEFLECTION 3208, QUADRANT 404.**

(2) *Grid Coordinates.* The observer may choose to map-spot the target location. The FDC uses all streamlined fire direction procedures previously discussed to compute data and announce fire commands.

**THIS IS Y69, IMMEDIATE SUPPRESSION, GRID 626417, OVER.**

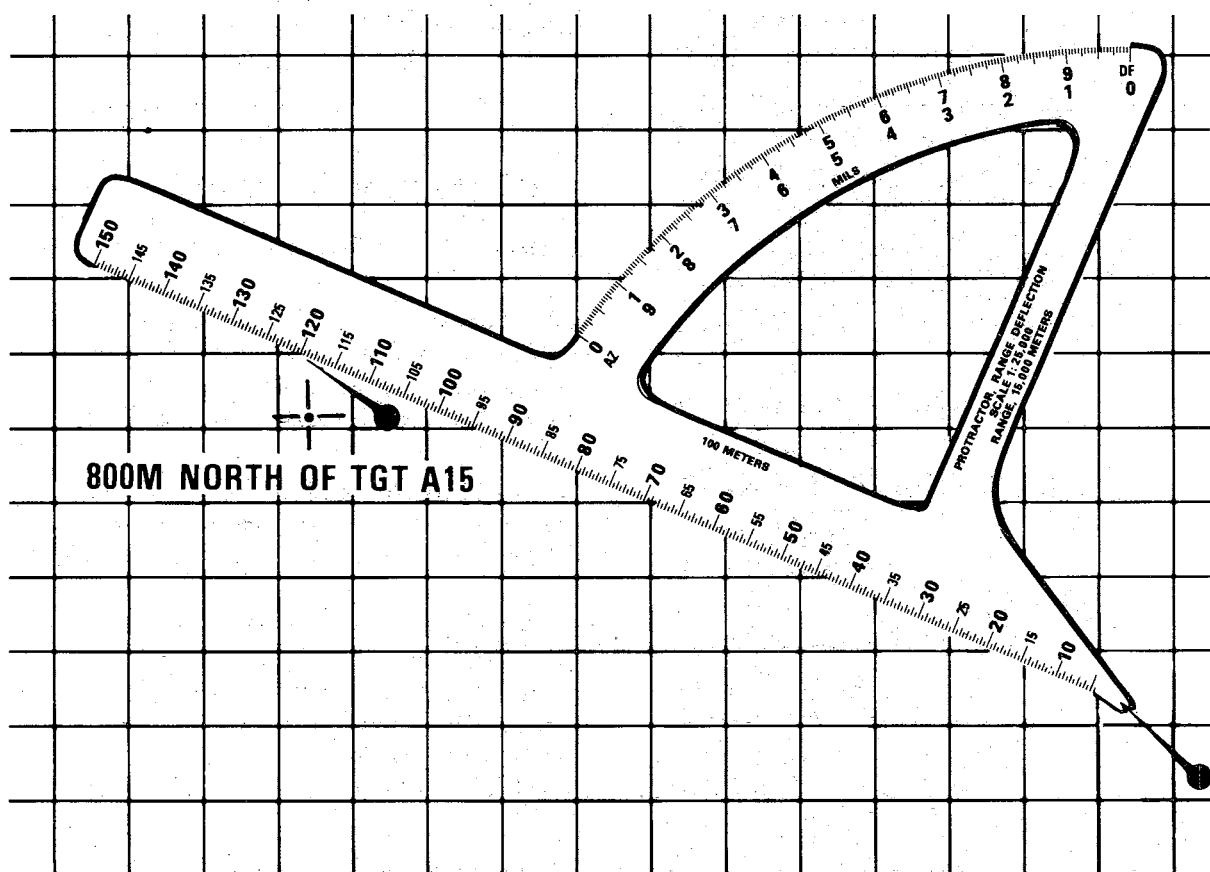


Figure 12-3. Shift from a preplanned target.

*c. Firing Data for Observer Subsequent Corrections.* If the initial volume of fire does not suppress the target, the observer may adjust onto the target. He must send his observer-target direction prior to, or along with, the first correction.

As suppressive fires are, in essence, fire for effect, the observer uses the term **REPEAT**, meaning he wants to maintain the same volume of fire. FDC personnel again use streamlined fire direction procedures to determine firing data as quickly as possible.

*d. Termination of Suppressive Fires.* The suppression mission is terminated in the usual manner:

If the maneuver commander or observer decides that the target should be neutralized, **END OF MISSION** is not sent. The observer uses standard observed fire procedures to continue the mission. He should include a description of the target as well as the term **ADJUST FIRE**.

When an adjust fire mission follows a suppression mission, the fire for effect should be delivered by the entire battery.

#### 12-4. Additional Duties of the Dedicated Battery FDO and Direct Support (DS) Battalion S3

*a. The FDO of the dedicated battery must:*

(1) Insure that firing data is developed for both preplanned targets and checkpoints. He directs that specific fuze settings be determined for each target or that a general fuze setting (based on min QE and min time) be used.

(2) Decide which platoon will lay on

which target based on priorities established by the maneuver commander and the FO.

(3) Insure that all maneuver control measures are posted in the FDC. During the operation, monitor the advance of the maneuver elements and post the movement on firing charts and situation maps.

(4) Direct platoons to re-lay on new targets and to prepare ammunition as priorities change and the movement progresses.

(5) Anticipate the needs of the maneuver force and be prepared to accept multiple missions.

*b. The DS battalion S3 must:*

(1) Position the dedicated battery in the best possible location to accomplish its mission.

(2) Give first priority on position survey to the dedicated battery.

(3) Coordinate with the battalion executive officer and S4 to insure that the dedicated battery has priority on maintenance and supply assistance.

(4) Coordinate with the battalion ammunition officer to insure that the dedicated battery has the appropriate amount and type of ammunition for its mission.

(5) Insure that current meteorological data is made available to the dedicated battery.

(6) Coordinate to provide engineer support, if available, to the dedicated battery for position hardening.

(7) Anticipate the needs of the dedicated battery and the possible shift of the dedicated battery role to another battery in the event of hostile actions, range limitations, or change in the scheme of maneuver.

(8) Insure that division artillery FDC personnel know the status of the dedication so that they will not plan to use dedicated batteries in massed fires.

(9) Be prepared to augment the fires of the dedicated battery.



## 12-5. Example

*a. Preparation for Dedication.* The battery has been assigned the mission of dedicated battery. Battery FDC personnel had completed all preparations to include:

- (1) Plotting all preplanned targets and checkpoints.
- (2) Establishing fire command standards and fire order standards.
- (3) Preparing an average site map for the area of operations.
- (4) Computing firing data for all targets and checkpoints.
- (5) Establishing platoon assignments for targets and checkpoints and sending all data to the guns.

*b. Situation.* The dedicated battery mission has started and the maneuver unit is moving to contact the enemy. The maneuver unit has proceeded past a prearranged phase line, and the FO has directed the FDC to shift platoon priorities to new targets. The maneuver unit encounters the enemy, and enemy direct fire systems have begun to fire. The observer locates a target approximately 800 meters west of checkpoint 7 and decides to suppress the target.

THIS IS THE IMMEDIATE SUPPRESSION 800 METERS WEST OF CHECKPOINT 70NTER 303

The VCO plots the shift and announces firing data determined from the GFT fan.

CHARGE 13 101 ELEVATION 303 ELEVATION 303

The FDO analyzes the target area and platoon assignments and issues an abbreviated fire order:

RIGHT PLATOON

The VCO determines the average site and announces it:

SITE PLUS 6

The computer determines firing data and announces abbreviated fire commands to the right platoon:

FIRE MISSION RIGHT PLATOON  
ROUNDS 101 ELEVATION 303  
QUADRANT 309

The platoon loads and fires as quickly as possible. The observer decides to adjust closer to the target:

DIRECTION 1010 RIGHT 50  
DROPTO 1010 1010

The VCO orients the target grid to the announced direction and plots the shift accordingly. Chart data is announced and the computer determines firing data. The data is sent to the guns and the rounds are fired.

## 12-6. FADAC Procedures

Procedures for computing a suppression mission using FADAC are the same as any other adjust fire or FFE mission. Average altitude is used if the target is located by grid and the appropriate fuze override (normally VT) is enabled. In many cases, data for the initial rounds is determined manually by the VCO using the GFT fan. If the observer makes any corrections, subsequent rounds may be fired using FADAC. This method may provide the greatest amount of responsiveness.

## Section II. TECHNIQUES FOR THE ATTACK OF LARGE TARGETS

The FDO must consider the size of a target in deciding how best to attack it. The Graphical Munitions Effectiveness Table should be used as a guide in determining the volume of fire to place on a target. Many times, however, targets are larger than those that can be considered with the GMET. The largest target considered by the GMET is 250 meters.

Large or irregularly shaped targets will require special fire distribution techniques to insure proper coverage with the most effective use of the ammunition available. This section describes various methods of attacking large targets that have proved successful. It does not include all methods, and the FDO and S3 should use the technique that best accomplishes the mission.

### 12-7. Target Division

In this method, the target is divided into a number of subtargets and each subtarget is fired on separately.

a. Targets significantly larger than the battery sheaf should be sent to battalion FDC for additional fires. There are times, however, when the battery will be forced to fire on targets larger than the battery sheaf. When this occurs, the battery FDO may divide the target to distribute his fires effectively.

#### Example:

(1) A call for fire from an observer is received by the battery FDC (fig 12-4).

M18 THIS IS M24 FIRE FOR  
EFFECT OVER  
GRID 948177 OVER  
SUSPECTED ATCM POSITION IN  
TREELINE LENGTH 400M  
TUDE 2100, OVER.

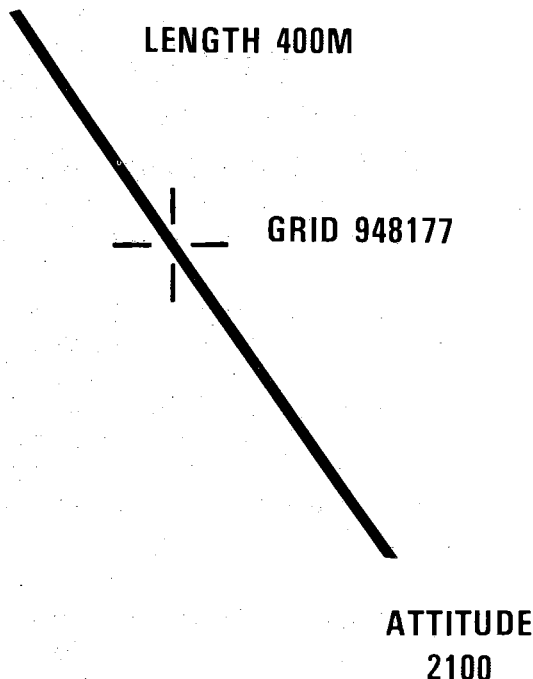


Figure 12-4. Target attitude

(2) The battery FDO requests additional fires from battalion, but the other batteries are engaged.

(3) The FDO can simply divide this target into two targets of 200-meter lengths each (fig 12-5). To do this, the FDO must compare the target attitude with the direction of fire to determine how best to divide the target. In this case, the battery would first fire on half the target, then fire on the other half.

b. The battalion FDO will normally divide large or irregularly shaped targets into subtargets for each battery. The appropriate subtargets are announced for each battery in the fire order. The subtargets announced to each battery may themselves require further division. The battalion FDO should issue guidance in his fire order as to how the subtarget should be subdivided.



**Example:**

A target is submitted to the battalion FDC by division artillery.

**GRID 617232, 600 BY 100, ATTITUDE 200.**

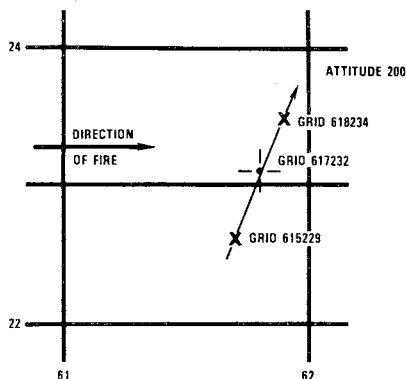


Figure 12-5. Division of a target into two 200-meter lengths.

(1) A map inspection indicates that the center battery can fire grid 617232, the leftmost battery fires grid 618234, the rightmost battery fires grid 615229.

(2) If the subtargets described above had required further subdivision (e.g., sweep and zone), the battalion FDO could have designated how the batteries were to attack the target:

**FIRE FOR EFFECT, BATTALION, ALPHA GRID 618234, BRAVO GRID 617232, CHARLIE GRID 615229, ALTITUDE 380, VT, EIGHT ROUNDS, SWEEP AND ZONE, TIME ON TARGET.**

(3) As an alternate method, the FDO could have said:

**FIRE FOR EFFECT, BATTALION, ALPHA GRID 618234, BRAVO GRID 617232, CHARLIE GRID 615229, ALTITUDE 380, ATTITUDE 200, PLACE BURSTS 60 METERS APART, VT, EIGHT ROUNDS, TIME ON TARGET.**

This indicates to each battery not only the center grid, but also the type of sheaf they are to fire.

c. The linear target table may be used to divide linear targets into platoon subtargets. Table 12-3 is for the 155-mm, but a table may be easily constructed for any caliber.

The left column lists the target length, the center column lists the number of meters each battery must add or drop along the long axis of the target to determine the center grid for its subtarget, and the right column lists the interval between platoon targets.

Table 12-3. Linear Target Table

| Tgt Length | +/- | Platoon Interval |
|------------|-----|------------------|
| 1500       | 700 | 165              |
| 1400       | 650 | 150              |
| 1300       | 600 | 140              |
| 1200       | 550 | 130              |
| 1100       | 500 | 120              |
| 1000       | 450 | 110              |
| 950        | 425 | 100              |
| 900        | 400 | 100              |
| 850        | 375 | 90               |
| 800        | 350 | 85               |
| 750        | 325 | 80               |
| 700        | 300 | 75               |
| 650        | 275 | 70               |
| 600        | 250 | 65               |
| 550        | 225 | 55               |
| 500        | 200 | 50               |

*Example:*

The battalion FDC receives the following call for fire.

**D26 THIS IS D12, FIRE FOR EFFECT, OVER.**

**GRID 938182, OVER.**

**INFANTRY COMPANY IN TREE-LINE, LENGTH 800, ATTITUDE 1900, OVER.**

(1) The chart operator plots the target and orients the target grid along the attitude of the target.

(2) All computers insure that each battery monitors the call for fire or passes the call for fire to the battery.

(3) Each battery chart operator also plots the target and orients the target grid.

(4) The battalion FDO examines the plot and, based on the attitude of the target with reference to the position of the firing batteries, determines that A Battery will attack the left portion of the target, B Battery the center of the target, and C Battery the right portion of the target. Based on this, the FDO issues the fire order:

**FIRE FOR EFFECT, BATTALION:  
ALPHA, LEFT PLATOON, DROP  
350, INTERVAL ADD 85; BRAVO,  
CENTER, INTERVAL 85; CHAR-  
LIE, RIGHT PLATOON, ADD 350,  
INTERVAL DROP 85; ALTITUDE  
370, 3 ROUNDS, TIME ON TAR-  
GET.**

(5) The A Battery chart operator drops 350 meters along the attitude and announces the chart data for the left platoon; he then adds 85 meters and announces the data for the center platoon, and adds another 85 meters and announces the data for the right platoon.

(6) The B Battery chart operator announces the chart data to the announced grid for the center platoon, adds 85 meters and announces the data for the right platoon, and drops 85 meters from the

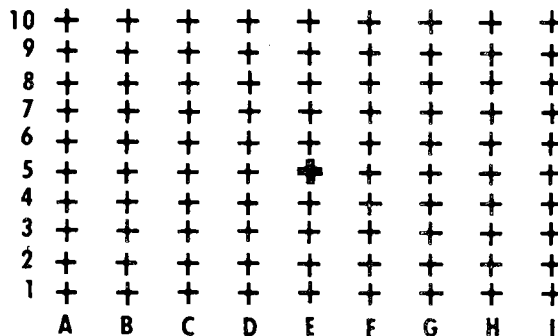
center of the target and announces the data for the left platoon.

(7) The C Battery chart operator adds 350 meters along the attitude and announces the chart data for the right platoon; he then drops 85 meters and announces the data for the center platoon and drops another 85 meters and announces the data for the left platoon.

### ★ 12-8. Massed Fire Distribution Template

In this method, the large or irregularly shaped target is plotted on the firing chart. A locally constructed massed fire distribution template drawn to scale for the firing chart is placed over the plotted target to allow the user to determine the optimum aimpoints for the required number of firing elements to mass fires.

*a. Constructing the Template.* Overlay paper is the best material for constructing the template. Each tickmark placed on the template represents an aimpoint for a firing element (fig 12-6). A separate template is required for each caliber, munition type, and size of firing element (one gun, platoon, or battery). (Refer to the appropriate JMEM for this information.) Distance between tickmarks is based on the radius of effects of the particular weapon system and munitions to be fired. (Refer to (C) FM 101-60-7, *Basic*



(NOT TO SCALE)

Figure 12-6. HE distribution template.

*Effectiveness Manual, Surface-to-Surface* (U), for this information.) Each tickmark represents the center of mass of rounds fired by a firing element.

b. *Using the Template.* Place the center tickmark (E-5 in fig 12-7) over the center of the target or the nearest grid intersection. Orient the template north-south on the firing chart or east-west if necessary for better coverage of the target area. Then determine points within the target area to attack to achieve effective results.

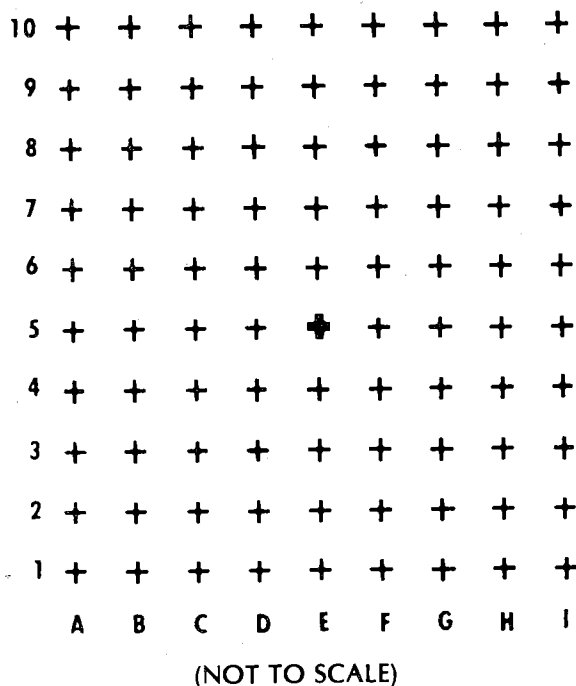


Figure 12-7. ICM distribution template.

### 12-9. Sweep and Zone Fires

Sweep, zone, or sweep and zone fires may be used to attack large targets. Surprise is lost as multiple volleys must be used, but a large area can be covered effectively.

a. *Sweep Fire.* When the width of the target is significantly large, sweep fires can be used to attack the target. In sweep fire, the firing unit fires a constant quadrant several deflections.

★ (1) To determine the number of deflections to be fired, the width of the target is divided by the firing unit's  $\frac{1}{4}$  standard sheaf width.

★ (2) To determine the sweep (in mils of deflection), the standard sheaf width is divided by the range to the target in thousands.

**AN ODD NUMBER OF DEFLECTIONS MUST ALWAYS BE FIRED.**

(3) The standard fire commands to the guns for sweeping fire are:

BATTERY \_\_\_\_\_ ROUNDS  
SWEEP \_\_\_\_\_ MILS  
\_\_\_\_\_ DEFLECTION

**BATTERY 1 ROUND  
SWEEP 40 MILS  
5 DEFLECTIONS**

#### *Example:*

An M109A1 battery is in position with a battery width of 250 meters. The FDC receives an urgent call for fire on a target 750 meters wide. The FDO decides to attack the target with sweep fires.

#### **GIVEN:**

Range to target: 5000 meters

Deflection to target: 3218 mils

Number of deflections to be fired.

$$\text{Step 1: } \frac{\text{Width of target}}{\text{Normal sheaf width}} = \frac{750}{250} = 3$$

Sweep (in mils of deflection)

$$\text{Step 2: } \frac{\text{Normal sheaf width}}{\text{Range to target (in 1000s)}} = \frac{250}{5} = 50$$

#### **Fire commands:**

**BATTERY ONE ROUND, SWEEP  
50 MILS, THREE DEFLECTIONS.**

#### **Deflections fired:**

The battery will fire df 3218 first, then the following deflections in any order: df 3268 and df 3168.

b. *Zone Fire.* When the depth of the target is larger than the depth of the normal battery sheaf, zone fire is a suitable technique for attacking the target. In zone fires, the firing

# C1, FM 6-40

battery fires in a constant deflection at several quadrant elevations. The FDC computes the number of quadrant elevations and the mil difference between quadrant elevations.

(1) Number of quadrant elevations to be fired can be determined by dividing the depth of the target by the normal sheaf depth.

**The number of QEs must always be an odd number.**

(2) Mil difference between quadrant elevations is determined as follows:

(a) Add the value of the normal sheaf depth to the range to the target.

(b) Determine the quadrant elevation for the range determined as in (a) above.

(c) Determine the quadrant elevation for the center range.

(d) Subtract the quadrant elevation for the center range from the quadrant elevation determined as in (b) above. The result is the zone (in mils).

(3) Zone fire is announced by the following fire commands.

BATTERY \_\_\_\_\_ ROUNDS  
ZONE \_\_\_\_\_ MILS  
\_\_\_\_\_ QUADRANTS

BATTERY 1 ROUND  
ZONE 7 MILS  
3 QUADRANTS

## ★ Example:

An M109A1 battery is in position. The FDC receives an urgent call for fire on a target that is 450 meters in depth. Target range is 5000 meters. Site is +4 mils. Charge 4 GB is being fired. Standard sheaf depth for M109A1 is 100 meters.

Number of quadrants to be fired:

$\frac{\text{Target depth}}{\text{Sheaf depth}} = \text{Number of QEs}$

$\frac{450}{100} \approx 5$

Five different quadrants are to be fired.

Difference in mils between quadrants.

Step 1:

Range to target 5000  
+ Normal sheaf depth + 100  
5100

Step 2: QE for range in step 1.

el  $\approx$  range 5100 302  
+ site + 4 mils  
306 QE

Step 3:

QE from step 2 306  
- QE for center range 5000  
(el 295 + site + 4 = 299) - 299  
Difference in mils 7

Quadrants fired:

The guns will fire QE 299, then will fire the following QEs in any order they desire:

QE 306

QE 313

QE 292

QE 285

c. *Sweep and Zone Fire.* When very wide and deep targets are to be attacked, sweep and zone fires can be used. The FDC procedures in computing sweep and zone fires are the combination of the procedures described for sweep fires and zone fires.

(1) The fire commands for sweep and zone fires are:

BATTERY \_\_\_\_\_ ROUNDS  
SWEEP \_\_\_\_\_ MILS  
\_\_\_\_\_ DEFLECTIONS  
ZONE \_\_\_\_\_ MILS  
\_\_\_\_\_ QUADRANTS

BATTERY 3 ROUNDS  
SWEEP 20 MILS  
5 DEFLECTIONS  
ZONE 4 MILS  
5 QUADRANTS

A single unit that employs sweep, zone, or sweep and zone fires is very vulnerable to detection and requires a great amount of ammunition. Vulnerability considerations may call for mass fires with multiple units rather than the sweep, zone, or sweep and zone by a single unit.

**Example:**

An M109A1 battery is in position with a 250-meter front. The FDC receives an urgent call for fire on a target that is 700 meters wide and 400 meters in depth. There are no other units available.

**GIVEN:**

Range to target: 6000 meters

Deflection to target: 3088 mils

Charge: 4 GB

Site: +2 mils

The FDO directs the computer to determine data for sweep and zone fires.

**Sweep Fire:**

Number of Deflections:  $700 \text{ meters} \div 250 \text{ meters} = 2.8 \approx 3$  deflections to be fired.

Size of Sweep:  $250 \text{ meters} \div 6 = 41.7 \approx 42$  mils.

**Zone Fire:**

Number of Quadrants:

$400 \text{ meters} \div 100 \text{ meters} = 4$

(The number of quadrants must be added)

Quadrants to be fired  $\frac{+1}{5}$

**Size of Zone:****Step 1:**

|                 |             |
|-----------------|-------------|
| Range to target | 6000        |
| + Sheaf depth   | 100         |
|                 | <u>6100</u> |

**Step 2:**

|                         |               |
|-------------------------|---------------|
| QE for range in step 1  | 385           |
| el $\approx$ range 6100 | +2            |
| + site                  | <u>387 QE</u> |

**Step 3:**

|                            |             |
|----------------------------|-------------|
| QE from step 2             | 387         |
| - QE for center range 6000 |             |
| (el 376 + si +2 = 378)     | <u>-378</u> |
| Difference in mils         | 9           |

**Fire commands:**

BATTERY ONE ROUND, SWEEP  
42 MILS,  
3 DEFLECTIONS  
ZONE 9 MILS, 5 QUADRANTS

**12-10. FADAC Procedures**

The FADAC may be used to subdivide large target using normal special corrections techniques. Initial sweep and/or zone data may be determined with FADAC as well as the number of mils between each deflection and/or quadrant shift.

## Section III. FINAL PROTECTIVE FIRE (FPF)

**12-11. Description**

A final protective fire (FPF) is an immediately available prearranged barrier of fire designed to protect friendly troops and installations by impeding enemy movements across defensive lines or areas. The normal use of an FPF is to establish prearranged close-in defensive fires, which include other artillery fires, minefields, obstacles, final protective machinegun lines and small-arms fire, and final protective fire of mortars. Each battery is assigned one FPF and normally is laid on that FPF when not firing other

missions. The FPF may be fired on prearranged signal or on call from the supported unit. The firing of an FPF may be repeated on call as often as necessary. When time and ammunition permit, the data for the FPF should be verified or corrected by the firing of check rounds. A battery FPF may be fired either individually or in coordination with those of other batteries.

a. *Width of FPF.* The width (or length) of the FPF that can be covered by a single battery without shifting its fire should not exceed the width of an open sheaf for the

battery concerned. When necessary, the width (length) of the FPF may be increased by agreement between the commanders of the artillery and the supported unit. However, the effectiveness of fire will be decreased.

*b. Preparation of Data.* The actual map location of the FPF is reported by the supported unit through the various fire support channels. The FPF is assigned to an artillery unit, which is responsible for computing the firing data. Since the FPF usually is located within a very short distance of positions occupied by friendly troops, precise computational procedures must be employed and all available corrections must be applied. Special corrections in the form of calibration corrections and position corrections, obtained by use of the M17 plotting board, are determined and applied as individual piece corrections. When the axis of the FPF is other than perpendicular to the direction of fire, additional computations must be made to bring each burst to a desired point on the FPF line.

★ *c. Call for Fire.* The call for fire for final protective fires is as outlined in FM 6-30, chapter 6.

## ★ 12-12. Computational Procedures

*a. Initial Data.* A battery one volley at 5-second intervals is fired initially to the center range and deflection with TGPC applied. This allows the observer to determine the flank piece and begin adjustment. Data fired is to the initial grid sent by the observer.

*b. Observer Adjusted FPF.* In an observer adjusted FPF, the observer selects the flank

piece closest to the desired FPF line. Using appropriate (danger close, if necessary) adjustment procedures, the observer adjusts the weapon onto the FPF line. Once the first gun is adjusted, the observer sends (next weapon) **NUMBER**, **REPEAT**. Initial firing data for the second weapon is the adjusted firing data from the first weapon. The observer then adjusts the second weapon onto the FPF line. The initial firing data for each succeeding piece is the adjusted firing data from the previous piece. This procedure continues until all weapons are adjusted. Adjusted FPF firing data is set off on each weapon between other fire missions. TGPC are continually used through each mission fired and are incorporated into the final data determined for the final protective fires (fig 12-8).

*c. FPF Not Adjusted.* When the situation does not permit the adjustment of each burst to its location on the FPF line, the following procedures are used:

(1) The call for fire includes the attitude of the FPF and the length, if different from that of an open sheaf.

(2) The FDC computes special corrections for each weapon using the M17 plotting board and special corrections for linear targets as discussed in chapter 8, section IV.

*d.* Upon completion of the adjustment phase of the FPF mission, the FDC informs each weapon of the final firing data to be used.

## 12-13. FADAC Procedures

FADAC should be used to determine the final grid for each piece using FADAC replot procedures. These grids should then be stored to facilitate the update of firing data.

### RECORD OF FIRE

| CALL FOR FIRE<br>Observer <b>H18</b> <b>AT FFE/IS/5</b> Tgt _____                                                                                            |    |                           |             |             |                          |            |    |             |                 | GFT R2<br>DFT L3    |             |             |             |              |              |              |      |                   |  | △ PS<br>100/R <b>34</b><br>/R<br>20/R<br>MOB Corr |  |               |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----|---------------------------|-------------|-------------|--------------------------|------------|----|-------------|-----------------|---------------------|-------------|-------------|-------------|--------------|--------------|--------------|------|-------------------|--|---------------------------------------------------|--|---------------|--|
| Grid: <b>628350</b><br>Polar: Dir _____ Dis _____ U/D _____ VA _____<br>Shift _____ Dir _____ L/R _____ U/D _____<br><b>FFE, ALTITUDE 1900, DANGER CLASE</b> |    |                           |             |             |                          |            |    |             |                 | Si ÷ 10      10m Si |             |             |             |              |              |              |      |                   |  |                                                   |  |               |  |
| FIRE ORDER <b>FFE, FPF. ① AT 5 Sec INTERNAL</b>                                                                                                              |    |                           |             |             |                          |            |    |             |                 | Df Corr <b>L1</b>   |             |             |             |              |              |              |      |                   |  | Si <b>+6</b>                                      |  |               |  |
| INITIAL FIRE COMMANDS <b>PM MF BTRY ①</b>                                                                                                                    |    |                           |             |             |                          |            |    |             |                 | Rg <b>3040</b>      |             |             |             |              |              |              |      |                   |  | Chf Df <b>3460</b>                                |  | EI <b>175</b> |  |
| Sp Instr <b>AT 5 SEC INTERVAL</b>                                                                                                                            |    |                           |             |             |                          |            |    |             |                 | Sh _____            |             | Lot _____   |             | Chg <b>4</b> |              | Fz _____     |      | Ti _____          |  | Df <b>3461</b>                                    |  | QE <b>181</b> |  |
| MTO <b>H47, ①</b>                                                                                                                                            |    |                           |             |             |                          |            |    |             |                 | T                   |             | PEg _____   |             | TF _____     |              | in Eff _____ |      | Ammo Exp <b>⑥</b> |  |                                                   |  |               |  |
| Tgt                                                                                                                                                          |    | Location                  | Priority    | Firing Unit | SUBSEQUENT FIRE COMMANDS |            |    |             |                 |                     |             |             |             |              |              |              |      |                   |  |                                                   |  |               |  |
| MF<br>Sh, Fz                                                                                                                                                 | MF | Dev                       | Rg          | MOB<br>Corr | MF, Sh,<br>Chg, Fz       | FS<br>Corr | Ti | Chart<br>Df | Df Corr<br>(LA) | Df<br>Fired         | Chart<br>Rg | MOB<br>Corr | Si<br>(+/-) | EI           | QE           | Exp          | Type |                   |  |                                                   |  |               |  |
| ① MF                                                                                                                                                         |    |                           |             |             |                          |            |    |             |                 |                     |             |             |             |              |              |              |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>000 #6 L40</b>         | <b>+100</b> |             | <b>#6 ADJ</b>            |            |    | <b>3468</b> | <b>L1</b>       | <b>3469</b>         | <b>3140</b> |             | <b>+6</b>   | <b>182</b>   | <b>188</b>   | <b>⑦</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>-50 #6</b>             |             |             |                          |            |    | <b>3471</b> | <b>L1</b>       | <b>(3472)</b>       | <b>3080</b> |             | <b>+6</b>   | <b>178</b>   | <b>(184)</b> | <b>⑧</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>IS ADJUSTED #5 RPT</b> |             |             | <b>#5 ADJ</b>            |            |    |             |                 | <b>3472</b>         |             |             |             |              | <b>184</b>   | <b>⑨</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>R20 +50 #5</b>         |             |             |                          |            |    | <b>3463</b> | <b>L1</b>       | <b>(3464)</b>       | <b>3130</b> |             | <b>+6</b>   | <b>181</b>   | <b>(187)</b> | <b>⑩</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>IS ADJUSTED #4 RPT</b> |             |             | <b>#4 ADJ</b>            |            |    |             |                 | <b>3464</b>         |             |             |             |              | <b>187</b>   | <b>⑪</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>-100</b>               |             |             |                          |            |    | <b>3466</b> | <b>L1</b>       | <b>3467</b>         | <b>3030</b> |             | <b>+6</b>   | <b>175</b>   | <b>181</b>   | <b>⑫</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>L10 +50 #4</b>         |             |             |                          |            |    | <b>3468</b> | <b>L1</b>       | <b>(3469)</b>       | <b>3080</b> |             | <b>+6</b>   | <b>178</b>   | <b>(184)</b> | <b>⑬</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>IS ADJUSTED #3 RPT</b> |             |             | <b>#3 ADJ</b>            |            |    |             |                 | <b>3469</b>         |             |             |             |              | <b>184</b>   | <b>⑭</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>R30 +100</b>           |             |             |                          |            |    | <b>3448</b> | <b>L1</b>       | <b>3449</b>         | <b>3180</b> |             | <b>+6</b>   | <b>184</b>   | <b>190</b>   | <b>⑮</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>-50 #3</b>             |             |             |                          |            |    | <b>3450</b> | <b>L1</b>       | <b>(3451)</b>       | <b>3130</b> |             | <b>+6</b>   | <b>181</b>   | <b>(187)</b> | <b>⑯</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>IS ADJUSTED #2 RPT</b> |             |             | <b>#2 ADJ</b>            |            |    |             |                 | <b>3451</b>         |             |             |             |              | <b>187</b>   | <b>⑰</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>R60 -100</b>           |             |             |                          |            |    | <b>3426</b> | <b>L1</b>       | <b>3427</b>         | <b>3020</b> |             | <b>+6</b>   | <b>174</b>   | <b>180</b>   | <b>⑱</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>+50 #2</b>             |             |             |                          |            |    | <b>3424</b> | <b>L1</b>       | <b>(3425)</b>       | <b>3060</b> |             | <b>+6</b>   | <b>177</b>   | <b>(183)</b> | <b>⑲</b>     |      |                   |  |                                                   |  |               |  |
|                                                                                                                                                              |    | <b>IS ADJUSTED #1 RPT</b> |             |             | <b>#1 ADJ</b>            |            |    |             |                 | <b>3425</b>         |             |             |             |              | <b>183</b>   | <b>⑳</b>     |      |                   |  |                                                   |  |               |  |
| (SEE ATCH'D ROF)                                                                                                                                             |    |                           |             |             |                          |            |    |             |                 |                     |             |             |             |              |              |              |      |                   |  |                                                   |  |               |  |
| Btry <b>B</b>                                                                                                                                                |    | DTG                       |             |             |                          | Tgt        |    |             |                 | Replot Grid         |             |             |             | Replot Alt   |              |              |      |                   |  |                                                   |  |               |  |

DA FORM 4504  
1 OCT 78

REPLACES DA FORM 4504, 1 MAY 76 , WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROPONENT AGENCY IS TRADOC

[illegible]

Figure 12-8. Sample mission, FPF.

## Section IV. AERIAL OBSERVERS AND UNTRAINED OBSERVERS

### 12-14. Aerial Observer Problems

Aerial observers (AO) often encounter three problems which require special assistance from the FDC.

a. The AO seldom has a fixed direction to the target. Normally, he is flying up and down, in and around the target area. Hence, FDC personnel must be prepared for unusual and changing observer directions or spotting lines.

b. The AO may lose his perception of distances while in the air. He may request ranging rounds (two rounds impacting 400 meters apart) as an aid to visualizing distances in the target area. The observer and FDC personnel must realize that ranging rounds fired along the gun-target line may disclose to the enemy the firing unit's general location.

c. The AO must minimize his exposure time to enemy detection. In forward areas, the pilot must fly close to the earth and behind cover as much as possible. The AO and his pilot therefore require from the FDC very accurate time of flight, shot, and splash, so that the pilot can "unmask" the aircraft 2 to 3 seconds before the impact of the round(s).

### 12-15. Observer Directions/Spotting Lines

a. *AO Uses Grid Coordinates and Gun-Target Line.* If the AO is knowledgeable of the location of the firing unit with respect to the target, he may choose to adjust along the gun-target line. When the AO announces:

**DIRECTION: GUN-TARGET  
LINE**

or implies GT line by his omission of a direction, the chart operator plots the target

and centers the target grid over the plot. To orient the target grid, he rotates it until the 03200 line (the center arrow) is parallel to gun-target line (the arm of the RDP).

b. *AO Uses Shift From a Known Point Along the Gun-Target Line.* The AO may designate **DIRECTION: GUN-TARGET LINE** for a shift from a known point. In this instance, the chart operator plots the known point, centers the target grid, and orients it for gun-target line. He plots the observer's shift and determines chart data. He then rotates the target grid around the new pinhole so that the arrow is parallel to the gun-target line (the arm of the RDP).

★ c. *AO Uses a Cardinal Direction.* The AO may choose to adjust along a cardinal direction, that is, one of the eight principal points of the compass (fig 12-9). When the observer announces a cardinal direction, the chart operator converts the direction into mils and orients the target grid to that direction. Direction southwest (SW) is converted to direction 4000 mils by the FDC.

d. *AO Uses Helicopter Instrument Readings for Direction.* When the AO's aircraft is changing locations and popping up and down, in and around the target area, the AO may use the aircraft instrument readings for his observer direction. As this direction is expressed in degrees, FDC personnel must convert the reading to mils by use of this relationship:

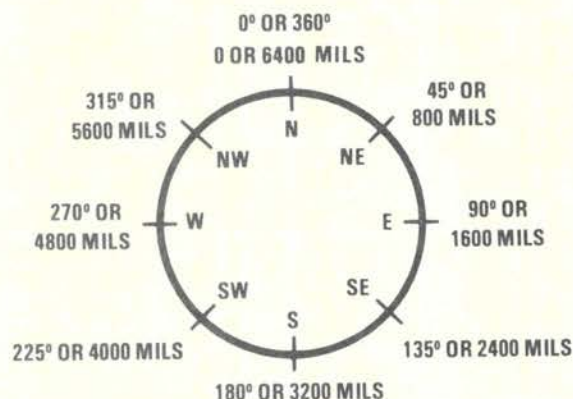
Direction in degrees  $\times 17.8$  = direction in mils

Direction:  $250^{\circ}$

$250^{\circ} \times 17.8$  mils = direction 4450 mils

*Note.* In preparation for AO missions, the VCO should mark a target grid in degrees or prepare a conversion chart for quick conversion from degrees to mils.





★ Figure 12-9. Cardinal directions.

e. *AO Uses a Spotting Line.* The AO may adjust along the line formed by a natural or manmade terrain feature, such as a road, railroad, canal, or ridge line. Prior to flight, if possible, the observer selects the line, determines the direction, and notifies FDC. While in flight, he may select a line that is readily identifiable and convenient. The AO may describe the feature in detail and have FDC personnel determine the direction from a map using a protractor. The chart operator orients the target grid on that direction.

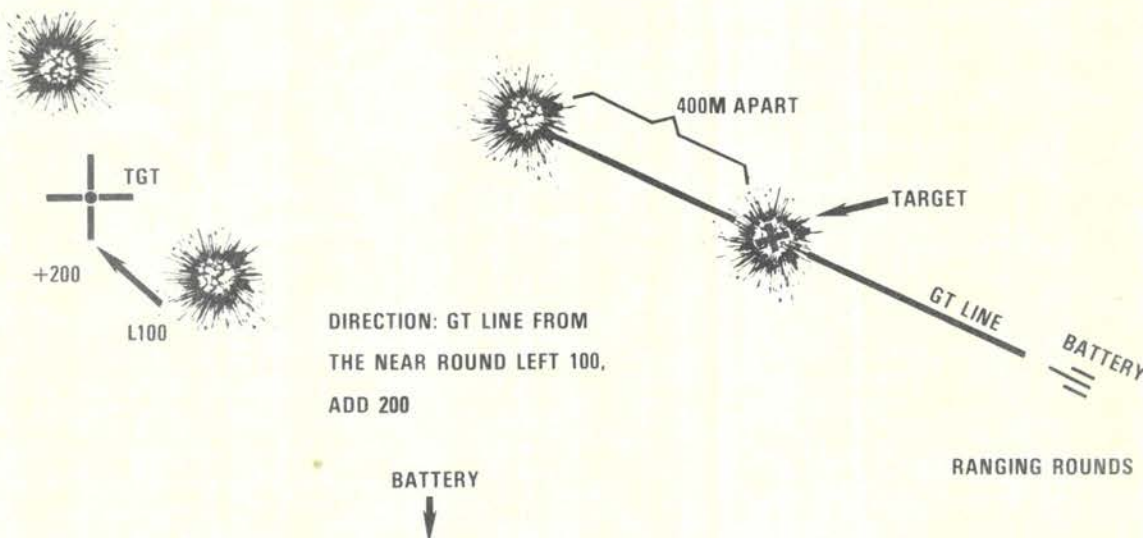
## 12-16. Ranging Rounds

★ In his call for fire, the AO may announce:

### REQUEST RANGING ROUNDS

This indicates that he desires to see a volley of two rounds that impact a distance of 400 meters apart at relatively the same time. (Ranging rounds are fired only as a last resort.) These rounds are fired along the gun-target line. The chart operator determines initial chart data, and the computer determines initial firing data for the adjusting piece. The computer then adds 400 meters to the announced chart range. Using the new range and the initial chart deflection, he determines firing data for the second piece to fire in the volley (usually, the other piece in the center platoon). The ranging rounds are fired simultaneously by firing **AT MY COMMAND**. When the AO observes the impact of the rounds and determines the corrections necessary to hit the target, he may base his corrections on whichever round landed closest to the target. He must specify to FDC from which round he is adjusting, and the chart operator plots the shift accordingly (fig 12-10).

### EXAMPLE CORRECTION



★ Figure 12-10. Ranging rounds.

### 12-17. Time of Flight/Shot/Splash

In the Message to Observer, the FDC must specify the time of flight. On all volleys, the FDC must promptly announce **SHOT** and **SPLASH**. The FDC should be watchful for changes in the time of flight as the mission progresses.

### 12-18. FADAC Procedures

Directions in degrees must be converted to mils for use in FADAC. When firing ranging rounds, the FADAC procedures parallel those for illumination, range spread. If the GT line override is left enabled, the FADAC will compute and use a new GT line for each subsequent correction. Normally, the first GT line computed (with the initial round) should be used throughout the mission. This is accomplished by disabling the GT LINE ADJUST override after the initial round data is computed.

### 12-19. Untrained Observer

Calls for fire from untrained personnel acting as observers require close attention and initiative from every member of FDC. When this situation arises, FDC personnel must be prepared to assist the untrained observer in his call for fire and adjustment of artillery. FDC personnel must:

a. Take the initiative if the observer is hesitant or confused in his request for fire support. FDC personnel must ask leading questions, such as:

(1) Where is the target?

(a) What are the grid coordinates of the target?

(b) Where is the target in relationship to a readily identifiable natural or manmade feature?

(c) Where are you, and how far is the target from you and in what direction?

(2) What is the target?

(a) What is the size of the enemy force?

(b) What are they doing at present?

(c) Which way are they headed?

(3) How close is the target to you? If they are within 600 meters or closer to other

friendly troops, the observer must "creep" the rounds to the target.

(4) What is your direction to the target?

(a) Azimuth in degrees or mils.

(b) Cardinal direction (N, NE, E, SE, S, SW, W, NW).

(c) Direction along a natural or manmade object.

(5) What effect do you need on the target?

(a) Is the target shooting at you?

(b) Is it necessary to obscure his vision?

(c) Do we need to neutralize or destroy the target?

b. Explain to the observer what artillery fire he is getting. The FDC must educate or inform the observer if necessary:

(1) You will see one round that will look like a cloud of dust. You will get more rounds when you move the burst within 50 meters or so of the target.

(2) The round(s) is now on the way and will impact in \_\_\_\_ seconds...Impact will be 5 seconds from NOW.

c. Assist the observer in making corrections. FDC personnel must help the observer move the rounds to the target and must be prepared for unusual shifts or combinations of shifts. To obtain corrections, they should ask leading questions, such as:

(1) Where did the round(s) land in relation to the target?

(a) Did it land LEFT or RIGHT? How much?

(b) Did it land OVER or SHORT? How much? Ask for dimensions in meters or in the number of football field lengths.

(2) Did the round land closer than the previous round?

d. Use sound judgment. FDC personnel must decide whether or not to require the observer to authenticate his mission. They must be on the watch for possible observer misorientation. Also, FDC personnel must assist the observer in determining when a satisfactory effect on the target has been achieved.



## Section V. ASSAULT FIRE

### 12-20. Definition

★ Assault fire is a special technique of indirect fire used to neutralize or destroy fixed fortifications such as cave positions or pillboxes (fig 12-11). In assault fire, one weapon, firing from defilade, fires at short range to obtain pinpoint accuracy on a stationary target. Normally, an FDC is employed for each weapon engaged in assault fire. The assault fire mission must be carefully planned and executed to achieve quick results with the minimum expenditure of ammunition. Standard observer and FDC procedures are employed in the adjustment phase; special procedures are used in fire for effect phase.

### 12-21. Weapons and Ammunition

a. *Weapons.* The artillery weapons best suited for assault fire in order of preference are the 8-inch howitzer, the 155-mm howitzer, and the 175-mm gun. The 105-mm projectile is considered uneconomical for assault fire on hard targets because of its limited destructive capability, but could be used on light targets.

b. *Ammunition.*

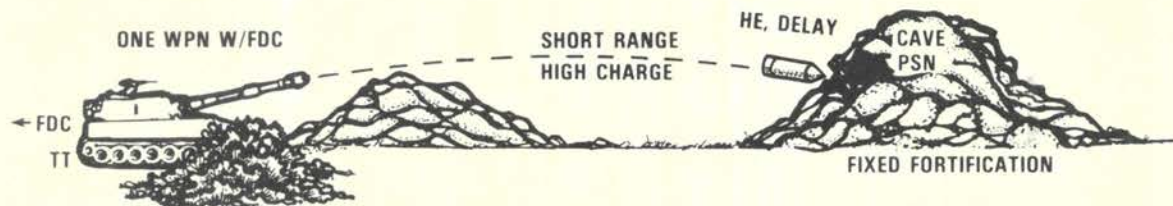
(1) *Projectile.* High explosive projectiles are used for assault fire.

(2) *Propellant.* The maximum charge that will clear all intervening crests is used in order to achieve the greatest muzzle velocity and maximum target penetration.

(3) *Fuzes.* Concrete-piercing (CP) fuzes are appropriate for destruction of fortifications. Fuze quick or fuze concrete-piercing, nondelay, is used for adjustment and for clearing away rubble. Fuze concrete-piercing, delay, may be used in fire for effect to effect penetration. Fuze M557, delay, may be used in fire for effect if concrete-piercing fuze is not available. Fuze M557, quick, is used to cut through a parapet or an earth covering after which the appropriate fuze, CP or M557, delay, is used to effect destruction of the fortification. If excessive ricochets result from the use of concrete-piercing delay fuze, nondelay fuze should be used until enough cratering has been effected to prevent ricochet of the delay fuze.

### 12-22. Computation of Firing Data

Standard observer and FDC procedures are used during the adjustment phase of an assault fire mission. Normally, FDC personnel must use a TFT to determine elevation as the GFT does not represent the short ranges associated with the high charges used in assault fire. In fire for effect, the observer determines deviation (LEFT and RIGHT) corrections and site (UP and DOWN) corrections to the nearest one-half meter for maximum accuracy of fires. FDC personnel prepare and use special cards to convert the observer corrections to changes in deflection and quadrant. In fire for effect, a two-man



★ Figure 12-11. Assault fire.

FDC team (consisting of the deflection computer and the quadrant computer) determines the firing data.

*a. Duties of the Deflection Computer.* Prior to the start of the assault fire mission, the deflection computer prepares a deflection shift card as follows:

(1) Determines the initial chart range to the target.

(2) Uses a GST to compute a deflection shift for an observer deviation correction of one-half meter.

(a) Places MHL of the GST over one-half (0.5) on the D scale.

(b) Aligns initial chart range on the C scale under the MHL.

(c) Reads the deflection shift (in mils) opposite the M gagepoint.

(3) Repeats the process for all other observer deviation corrections. For observer deviation corrections of  $\frac{1}{2}$ , 1, and 2 meters, rounds the answer to the nearest  $\frac{1}{4}$  mil. For corrections greater than 2 meters, rounds to the nearest whole mil.

(4) Determines the deflection to be fired:

(a) Uses the deflection shift card to convert the observer deviation correction into a deflection shift.

(b) Uses the LARS rule (LEFT, ADD; RIGHT, SUBTRACT) to apply this deflection shift to the last deflection fired.

*b. Duties of the Quadrant Computer.*

(1) The quadrant computer uses the same procedures as the deflection computer to prepare a quadrant change card.

*Note.* For observer site corrections of  $\frac{1}{2}$ , 1, and 2 meters, express the quadrant change to the nearest  $\frac{1}{10}$  mil. For corrections greater than 2 meters, express it to the nearest whole mil.

(2) Determines the quadrant to be fired:

(a) Uses the quadrant change card to convert the observer site correction to a quadrant change.

(b) Applies the quadrant change to the last quadrant fired.

*Example:*

Situation: An M109A1 155-mm howitzer has been emplaced for an assault fire mission. The mission has progressed into the fire for effect phase. The range to the target is 1500 meters. Standard FO and FDC procedures are used until the first round in FFE is fired.

Deflection shift and quadrant change cards are prepared as shown in figure 12-12.

The first round in FFE is fired at df 3210, QE 030, chg 7.\*

| LAST DF FIRED      | OBSERVER DEV CORR | DF SHIFT                | NEW DF             |
|--------------------|-------------------|-------------------------|--------------------|
| LAST QE FIRED      | OBSERVER SI CORR  | QE CHANGE               | NEW QE             |
| 3210               | RIGHT 7           | RIGHT (-) 5             | 3205               |
| 30.0               | UP 4              | UP (+) 3                | 33.0               |
| 3205               | LEFT 4            | LEFT (+) 3              | 3208               |
| 33.0               | DOWN 2            | DOWN (-) 1.4            | 31.6               |
| 3208               | LEFT 2            | LEFT (+) $1\frac{1}{4}$ | 3209 $\frac{1}{4}$ |
| 31.6               | UP $\frac{1}{2}$  | UP (+) 0.3              | 31.9               |
| 3209 $\frac{1}{4}$ | RIGHT 1           | RIGHT (-) $\frac{3}{4}$ | 3208 $\frac{1}{2}$ |
| 31.9               | —                 | No Change               | 31.9               |

FO: END OF MISSION, BUNKER DESTROYED, OVER.

\*Although FFE range is 1740 meters, initial chart range is used to prepare the deflection shift and quadrant change cards.

**INITIAL CHART RG: 1500 METERS**

| Observer's deviation<br>Correction (in meters) | Deflection shift<br>(in mils) |
|------------------------------------------------|-------------------------------|
| ½                                              | ¼                             |
| 1                                              | ¾                             |
| 2                                              | 1¼                            |
| 3                                              | 2                             |
| 4                                              | 3                             |
| 5                                              | 3                             |
| 6                                              | 4                             |
| 7                                              | 5                             |
| 8                                              | 5                             |
| 9                                              | 6                             |
| 10                                             | 7                             |

**DEFLECTION SHIFT CARD**

**INITIAL CHART RG: 1500 METERS**

| Observer's site<br>Correction (in meters) | Quadrant change<br>(in mils) |
|-------------------------------------------|------------------------------|
| ½                                         | 0.3                          |
| 1                                         | 0.7                          |
| 2                                         | 1.4                          |
| 3                                         | 2                            |
| 4                                         | 3                            |
| 5                                         | 3                            |
| 6                                         | 4                            |
| 7                                         | 5                            |
| 8                                         | 5                            |
| 9                                         | 6                            |
| 10                                        | 7                            |

**QUADRANT CHANGE CARD**

★ Figure 12-12. Deflection shift and quadrant change cards.

**12-23. FADAC Procedures**

FADAC data may be used until fire for effect is entered. The normal manual procedures then must be used.

★ **12-24. Observer Procedures**

*a. Preparatory Operations.* The observer and all personnel concerned with an assault fire mission should prepare detailed plans for the mission. Thorough planning,

reconnaissance, and coordination must be completed before the weapon position is occupied. The observer must occupy an OP as near as possible to the target and on or near the gun-target line.

*b. Initial Data.* Normally, personnel prepare initial data in advance by use of the best means available (usually survey) to locate the target with respect to the assault weapon position. Therefore, in most cases, a complete call for fire from the observer is not necessary.

*c. Adjustment.* The observer uses a modified adjustment procedure in which he has complete control of fire throughout the mission. He gives corrections in meters for each successive round until the point of impact is on the desired portion of the target. The observer corrects an off-line burst to bring subsequent bursts to the line through normal adjustment procedures except that he gives deviation corrections to the nearest meter. He brackets the target for range and successively splits the bracket.

*d. Fire for Effect.* When the observer splits a 50-meter range bracket, he is in fire for effect although no announcement of fire for effect is made. At this time, the observer usually can estimate vertical error more accurately than he can estimate range error. Therefore, the observer makes corrections for altitude rather than range. After a 50-meter range bracket has been split, the smallest appropriate correction in direction or altitude is one-half meter. The observer continues to send a correction to the FDC for each round fired. All rounds are fired singly or as requested by the observer to permit the desired corrections or changes in ammunition to be made between rounds. The observer is responsible for controlling and ending the mission.

*e. Sample Mission.* The target is a concrete pillbox on the forward slope of a hill. The pillbox has several gun ports from which machineguns are firing; one opening faces the observer. The mission is to neutralize the

pillbox. The materiel is a 155-mm howitzer (SP); gun-target range is 2,000 meters; observer-target distance is 500 meters. The mission has been prearranged in detail, and a complete call for fire is unnecessary. The observer reports when he is ready to adjust, and the FDC announces commands to the gun to fire the first round. Table 12-4 reflects the sequence of events.

Table 12-4. Conduct of Assault Fire

| ★ Remarks                                                                                                          | Observer corrections                                                                     |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| First round bursts 20 mils right of OT line, short on terrain.                                                     | <b>LEFT 10,<br/>ADD 50, OVER</b>                                                         |
| Second round bursts 8 mils left of OT line, over on terrain.                                                       | <b>RIGHT 4,<br/>DROP 25, OVER</b>                                                        |
| Third round strikes pillbox 4 mils above center. (Vertical instead of range changes are now appropriate.)          | <b>CONCRETE-PIERCING, DELAY, DOWN 2, OVER</b>                                            |
| Fourth round strikes at lower left corner of opening.                                                              | <b>RIGHT 1/2, UP 1, OVER</b>                                                             |
| Fifth round strikes center causing great damage.                                                                   | <b>REPEAT, OVER</b>                                                                      |
| Sixth round strikes same hole. Rubble now closing opening. (Observer requests nondelay fuze to blast away rubble). | <b>CONCRETE-PIERCING, NONDELAY, REPEAT, OVER</b>                                         |
| Seventh round strikes pile of rubble, blasting most of it away.                                                    | <b>CONCRETE-PIERCING, DELAY, REPEAT, OVER</b>                                            |
| Eighth round pierces pillbox, explodes inside. No further activity from pillbox.                                   | <b>END OF MISSION, PILLBOX DESTROYED, RESISTANCE CEASED, ESTIMATE 6 CASUALTIES, OVER</b> |

## Section VI. ZONE-TO-ZONE TRANSFORMATION

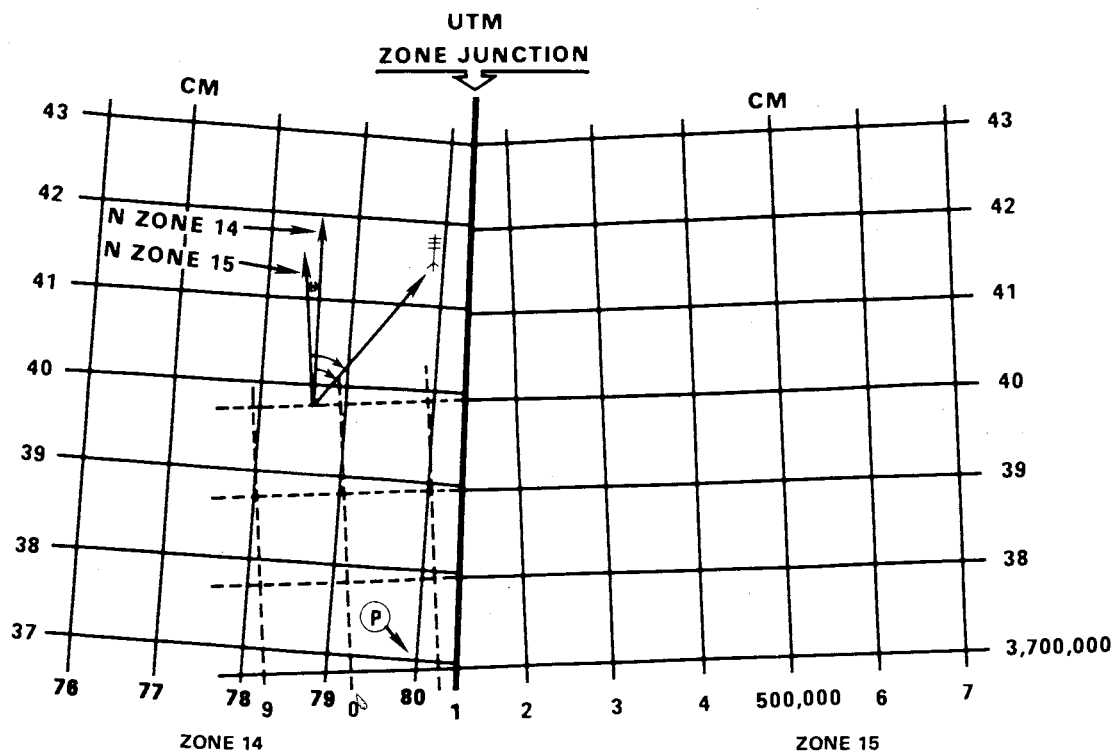
### ★ 12-25. Description

a. Zone-to-zone transformation is the technique of changing the coordinates and/or azimuths as expressed in one zone to coordinates and/or azimuths of the adjacent zone.

b. In the universal transverse mercator (UTM) grid system, there are 60 areas around the world where artillery units may have to

fire across UTM zone junctions. When this occurs, it is necessary to transform the grid coordinates of points and grid azimuths of lines of one zone to those of the adjacent zone.

c. Figure 12-13 shows two adjacent UTM zones, 14 and 15. The coordinates for P in the 14th zone are 800 370. If P were to be expressed in the terms of zone 15, its coordinates would be much different. The



★ Figure 12-13. Adjacent UTM zones.

same situation exists in terms of direction from point X to trig marker T. In zone 14, it is obviously different from what it would be in zone 15.

d. Zone-to-zone transformation can be accomplished by three means:

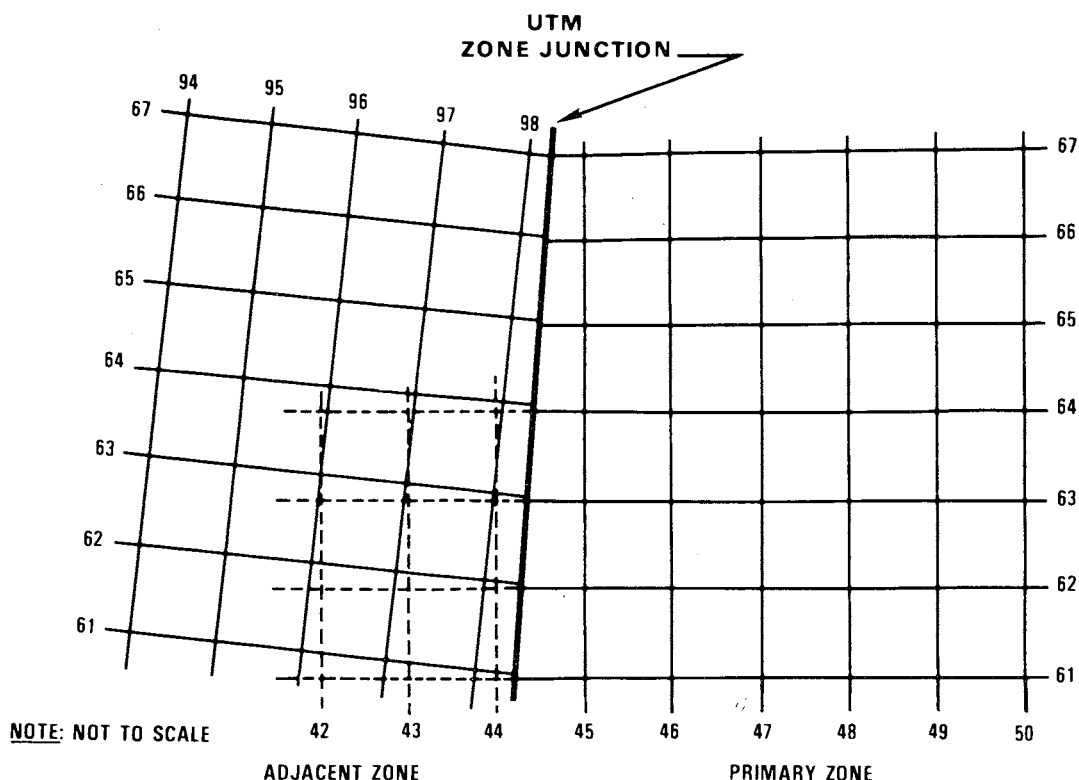
- (1) Cutting and joining two grid sheets.
- (2) Using graphic method.
- (3) Using computational method.

e. Maps printed by the Army Map Service show the differences between UTM grid zones. Maps that cover an area within 25 miles of a UTM zone junction are printed around the border with two sets of gridline numbers—one set for each zone. One set is printed in black; the other set is printed in blue and corresponds to the adjoining grid zone. Marginal information on the maps also indicates the color that applies to each zone.

#### ★ 12-26. Cutting and Joining Two Grid Sheets

a. *General.* The fastest and simplest method of zone-to-zone transformation is cutting and joining two grid sheets. Two grid sheets are prepared and joined to form a large chart (a constructed grid sheet) from which chart data across the zone junction can be determined automatically (fig 12-14).

b. *Preparation of Grid Sheets.* The chart operator prepares a piece of chart paper (a grid sheet) for each grid zone involved. Using a plotting scale and sharp pencil, the chart operator reproduces on the grid sheets the exact orientation of the zone junction longitudinal and latitudinal lines as they appear on the map(s) of the area of overlap. The edges that are to be joined should be marked with a fine line based on accurate measurements taken from the map(s). Care in cutting and taping should be taken so that,



★ Figure 12-14. Joining of two grid sheets for zone-to-zone transformation.

when the sheets are put together to form one large chart, measurements from this large chart can be made accurately.

c. *Use of the Constructed Grid Sheet.* When firing data is determined from a constructed grid sheet, no transformation or computations are necessary. The coordinates are measured and plotted from the gridlines for the respective area(s). The observer's azimuth is used as announced, and the target grid is emplaced using grid north of the observer's zone.

## ★ 12-27. Graphic Method

a. *Designation of the Primary Zone.* Either of the UTM zones may be designated as the primary zone. Designation of the primary zone is based on the tactical situation, unit SOP, the directives of the commander, or the anticipated location of future operations.

### b. Preparation of the Map(s)

(1) Once the primary zone has been designated, the map(s) of each zone should be prepared for transformation. If more than one map is used, the two maps are lined up along the common UTM zone junction longitudinal line.

(2) The FDO and a chart operator, using the arm of the RDP or a long straightedge ruler, trace the gridlines of the primary zone into the secondary zone on the map.

(3) The east-west gridlines of the primary zone are extended by using the tick-mark around the border and are numbered with the appropriate values. The north-south gridlines are constructed similarly. The superimposed gridlines should be drawn with a distinctive colored pen to facilitate the rapid transformation of data and to reduce the possibility of errors.



*c. Procedure for Determining Chart Data.*

(1) The firing chart is numbered using the number designations of the gridlines of the primary zone.

(2) When the call for fire is received and the observer's target location lies in the adjacent zone, the target location is plotted on the map by using the normal gridlines of the adjacent zone.

(3) A new set of coordinates is determined for the target using the superimposed gridlines of the primary zone. These new coordinates are plotted on the firing chart, and chart data is determined using standard fire direction procedures.

(4) For adjust missions, the next step is to convert the observer direction in the secondary zone to the corrected direction in the primary zone. (In this case, the observer has not done this previously using his own map(s).)

(5) The correction factor applied to the observer's direction is computed using table 14 of the current Army Ephemeris (FM 6-300-current year (fig 12-15)) as follows:

| N          | C      | DIFF IN C | ALLOWABLE<br>DIFF IN N | F     |
|------------|--------|-----------|------------------------|-------|
| 0          | 0.0    | .842      | ★                      | ★     |
| 100 000    | 0.842  | .842      | 0.18                   | 15.24 |
| 200 000    | 1.684  | .841      | 0.26                   | 7.62  |
| 300 000    | 2.525  | .842      | 0.31                   | 5.08  |
| 400 000    | 3.367  | .841      | 0.36                   | 3.81  |
| 500 000    | 4.208  | .841      | 0.40                   | 3.05  |
| 600 000    | 5.049  | .841      | 0.44                   | 2.54  |
| 700 000    | 5.890  | .840      | 0.48                   | 2.18  |
| 800 000    | 6.730  | .840      | 0.51                   | 1.91  |
| 900 000    | 7.570  | .840      | 0.54                   | 1.70  |
| 1 000 000  | 8.410  | .840      | 0.57                   | 1.51  |
| 1 100 000  | 9.250  | .840      | 0.60                   | 1.31  |
| 1 200 000  | 10.090 | .840      | 0.63                   | 1.11  |
| 1 300 000  | 10.930 | .840      | 0.66                   | 0.91  |
| 1 400 000  | 11.770 | .840      | 0.69                   | 0.71  |
| 1 500 000  | 12.610 | .840      | 0.72                   | 0.51  |
| 1 600 000  | 13.450 | .840      | 0.75                   | 0.31  |
| 1 700 000  | 14.290 | .840      | 0.78                   | 0.11  |
| 1 800 000  | 15.130 | .840      | 0.81                   | 0.00  |
| 1 900 000  | 15.970 | .840      | 0.84                   | 0.00  |
| 2 000 000  | 16.810 | .840      | 0.87                   | 0.00  |
| 2 100 000  | 17.650 | .840      | 0.90                   | 0.00  |
| 2 200 000  | 18.490 | .840      | 0.93                   | 0.00  |
| 2 300 000  | 19.330 | .840      | 0.96                   | 0.00  |
| 2 400 000  | 20.170 | .840      | 0.99                   | 0.00  |
| 2 500 000  | 21.010 | .840      | 1.02                   | 0.00  |
| 2 600 000  | 21.850 | .840      | 1.05                   | 0.00  |
| 2 700 000  | 22.690 | .840      | 1.08                   | 0.00  |
| 2 800 000  | 23.530 | .840      | 1.11                   | 0.00  |
| 2 900 000  | 24.370 | .840      | 1.14                   | 0.00  |
| 3 000 000  | 25.210 | .840      | 1.17                   | 0.00  |
| 3 100 000  | 26.050 | .840      | 1.20                   | 0.00  |
| 3 200 000  | 26.890 | .840      | 1.23                   | 0.00  |
| 3 300 000  | 27.730 | .840      | 1.26                   | 0.00  |
| 3 400 000  | 28.570 | .840      | 1.29                   | 0.00  |
| 3 500 000  | 29.410 | .840      | 1.32                   | 0.00  |
| 3 600 000  | 30.250 | .840      | 1.35                   | 0.00  |
| 3 700 000  | 31.090 | .840      | 1.38                   | 0.00  |
| 3 800 000  | 31.930 | .840      | 1.41                   | 0.00  |
| 3 900 000  | 32.770 | .840      | 1.44                   | 0.00  |
| 4 000 000  | 33.610 | .840      | 1.47                   | 0.00  |
| 4 100 000  | 34.450 | .840      | 1.50                   | 0.00  |
| 4 200 000  | 35.290 | .840      | 1.53                   | 0.00  |
| 4 300 000  | 36.130 | .840      | 1.56                   | 0.00  |
| 4 400 000  | 36.970 | .840      | 1.59                   | 0.00  |
| 4 500 000  | 37.810 | .840      | 1.62                   | 0.00  |
| 4 600 000  | 38.650 | .840      | 1.65                   | 0.00  |
| 4 700 000  | 39.490 | .840      | 1.68                   | 0.00  |
| 4 800 000  | 40.330 | .840      | 1.71                   | 0.00  |
| 4 900 000  | 41.170 | .840      | 1.74                   | 0.00  |
| 5 000 000  | 42.010 | .840      | 1.77                   | 0.00  |
| 5 100 000  | 42.850 | .840      | 1.80                   | 0.00  |
| 5 200 000  | 43.690 | .840      | 1.83                   | 0.00  |
| 5 300 000  | 44.530 | .840      | 1.86                   | 0.00  |
| 5 400 000  | 45.370 | .840      | 1.89                   | 0.00  |
| 5 500 000  | 46.210 | .840      | 1.92                   | 0.00  |
| 5 600 000  | 47.050 | .840      | 1.95                   | 0.00  |
| 5 700 000  | 47.890 | .840      | 1.98                   | 0.00  |
| 5 800 000  | 48.730 | .840      | 2.01                   | 0.00  |
| 5 900 000  | 49.570 | .840      | 2.04                   | 0.00  |
| 6 000 000  | 50.410 | .840      | 2.07                   | 0.00  |
| 6 100 000  | 51.250 | .840      | 2.10                   | 0.00  |
| 6 200 000  | 52.090 | .840      | 2.13                   | 0.00  |
| 6 300 000  | 52.930 | .840      | 2.16                   | 0.00  |
| 6 400 000  | 53.770 | .840      | 2.19                   | 0.00  |
| 6 500 000  | 54.610 | .840      | 2.22                   | 0.00  |
| 6 600 000  | 55.450 | .840      | 2.25                   | 0.00  |
| 6 700 000  | 56.290 | .840      | 2.28                   | 0.00  |
| 6 800 000  | 57.130 | .840      | 2.31                   | 0.00  |
| 6 900 000  | 57.970 | .840      | 2.34                   | 0.00  |
| 7 000 000  | 58.810 | .840      | 2.37                   | 0.00  |
| 7 100 000  | 59.650 | .840      | 2.40                   | 0.00  |
| 7 200 000  | 60.490 | .840      | 2.43                   | 0.00  |
| 7 300 000  | 61.330 | .840      | 2.46                   | 0.00  |
| 7 400 000  | 62.170 | .840      | 2.49                   | 0.00  |
| 7 500 000  | 63.010 | .840      | 2.52                   | 0.00  |
| 7 600 000  | 63.850 | .840      | 2.55                   | 0.00  |
| 7 700 000  | 64.690 | .840      | 2.58                   | 0.00  |
| 7 800 000  | 65.530 | .840      | 2.61                   | 0.00  |
| 7 900 000  | 66.370 | .840      | 2.64                   | 0.00  |
| 8 000 000  | 67.210 | .840      | 2.67                   | 0.00  |
| 8 100 000  | 68.050 | .840      | 2.70                   | 0.00  |
| 8 200 000  | 68.890 | .840      | 2.73                   | 0.00  |
| 8 300 000  | 69.730 | .840      | 2.76                   | 0.00  |
| 8 400 000  | 70.570 | .840      | 2.79                   | 0.00  |
| 8 500 000  | 71.410 | .840      | 2.82                   | 0.00  |
| 8 600 000  | 72.250 | .840      | 2.85                   | 0.00  |
| 8 700 000  | 73.090 | .840      | 2.88                   | 0.00  |
| 8 800 000  | 73.930 | .840      | 2.91                   | 0.00  |
| 8 900 000  | 74.770 | .840      | 2.94                   | 0.00  |
| 9 000 000  | 75.610 | .840      | 2.97                   | 0.00  |
| 9 100 000  | 76.450 | .840      | 3.00                   | 0.00  |
| 9 200 000  | 77.290 | .840      | 3.03                   | 0.00  |
| 9 300 000  | 78.130 | .840      | 3.06                   | 0.00  |
| 9 400 000  | 78.970 | .840      | 3.09                   | 0.00  |
| 9 500 000  | 79.810 | .840      | 3.12                   | 0.00  |
| 9 600 000  | 80.650 | .840      | 3.15                   | 0.00  |
| 9 700 000  | 81.490 | .840      | 3.18                   | 0.00  |
| 9 800 000  | 82.330 | .840      | 3.21                   | 0.00  |
| 9 900 000  | 83.170 | .840      | 3.24                   | 0.00  |
| 10 000 000 | 84.010 | .840      | 3.27                   | 0.00  |

★ F CORRECTION NOT REQUIRED

★ Figure 12-15. Table 14 of the Army Ephemeris (FM 6-300).

(a) Determine the northing coordinate (seven significant digits) of the target in the primary zone, using the superimposed gridlines. Also determine the northing coordinate of the target using the printed gridlines.

(b) Add the values of the coordinates and divide the sum by 2 to obtain the average northing.

|                |                             |
|----------------|-----------------------------|
| Primary grid   |                             |
| from map       | 5551650                     |
| Secondary grid |                             |
| from FO        | + 5552100                   |
|                | $11103750 \div 2 = 5551875$ |

(c) Enter column N of table 14 using the average northing and latitude of the target at the nearest listed value. Find the correction factor in mils in column C. The nearest listed value to 5551875 is 5600000. The correction factor then is 45.598.

(d) Express the correction factor to the nearest 10 mils ( $45.598 \approx 50$ ) and apply it to the observer-target direction by the following rules. When the point is transformed in the:

#### NORTHERN HEMISPHERE

From east to west, the sign is -,  
From west to east, the sign is +.

---

#### SOUTHERN HEMISPHERE

From east to west, the sign is +,  
From west to east, the sign is -.

When the observer is in the Southern Hemisphere, the average northing coordinate must be subtracted from 10,000,000 before entering the table.

(6) The corrected direction is used to orient the target grid, and the chart data for the adjustment is determined using standard fire direction procedures.

|                     |                   |
|---------------------|-------------------|
| East to west        |                   |
| transformation      | sign is minus (-) |
| Direction (azimuth) | 1870 mils         |
| + Correction factor | + (-50)           |
| Corrected direction | 1820 mils         |

*d. Procedure When the Observer Locates the Target by Polar Plot or Shift from a Known Point.*

(1) *Polar plot.* A corrected direction must first be determined before plotting the target location on the firing chart. In this case, the northing coordinates of the observer's location in both zones are used to determine the average northing.

(2) *Shift from a known point.* The corrected direction once again must be determined prior to plotting the target. In this case, the northing coordinates of the known point are used to obtain the average northing. The target grid is oriented using the corrected direction, then the shift is plotted in the usual manner.

#### e. Observer Procedures.

(1) The discussion above has been for an observer located in the secondary zone and the battery in the primary zone. This situation requires no special action by the observer. He determines target location and OT direction as he does for any mission. He is not required to superimpose an additional grid over his map(s).

(2) When the observer sends target location, he must prefix his grid with the letter designator of the UTM grid zone in which he is located.

#### Example:

**ADJUST FIRE, GRID PK 515478**

#### f. Procedures When Observer is in Primary Zone and Battery is in Secondary Zone.

(1) Either zone may be designated as the primary zone. The procedures are essentially the same in both cases. The firing battery and the target or observer must be plotted on a common grid when the firing chart is constructed. The OT direction must be corrected prior to orienting the target grid for plotting subsequent corrections.

(2) Because the battery may have to fire into either zone, when the observer's grid zone is designated as primary, the following alternatives exist.

(a) The firing battery will have to be plotted twice on the firing chart, necessitating double numbering.

(b) Two charts will have to be constructed.

(c) One chart covering both zones will have to be constructed. This requires superimposing one grid over another.

#### ★ 12-28. FADAC Procedures

Matrix 2 contains a subroutine for grid and observer direction transformation. The FADAC should be used for these computations when possible. If the area of

responsibility (target area) lies in two zones, the battery grid may be entered in two firing units—one for each zone. The proper grid coordinates for each zone would be used; all other known data would be the same. The FADAC operator would depress the firing unit button for the zone in which the target is located to compute firing data. Observers would also be stored twice—once for each zone.

## ★ Section VII. FDC PROCEDURES FOR LASER RANGEFINDERS

#### 12-29. Observer Self-Location Using Two Known Points

a. An observer equipped with a laser rangefinder G/VLLD or AN/GVS-5 can use its accurate ranging capability to improve his estimated self-location. Known point locations may be determined by two methods:

(1) The observer may provide eight-place grids for two known points.

(2) The observer may give the general location (six-place grid) and description of the two known points.

Once the known point locations have been established between the observer and the FDC, the observer reports G/VLLD polar data to the FDC for each of the points.

b. To determine the observer's location, plot the known points on the firing chart. From each known point, construct an arc at the distance reported by the observer, generally along the back azimuth determined by the observer's reported direction. The intersection of the two arcs is the observer's location.

c. Plot the observer's location and determine the correct azimuth to the first known plot. Encode and send the location of

the observer and the azimuth to the first point. Altitude can be determined from the site map along with the observer's location, which should be stored in FADAC and plotted on the firing chart.

#### 12-30. Observer Self-Location With One Known Point and One Round

a. If only one known point can be established by the observer, a second known point may be established by firing a round, HE or WP, at a location selected by the observer. The round fired may be either an airburst or a graze burst.

b. FDC procedures are the same for determining the observer's location except the location to which the round was fired is used as the second known point. For those observers with G/VLLD or GVS-5, the round should not be fired until registration corrections have been applied at the battery.

#### 12-31. Observer Location Using Two Rounds

FDC procedures for determining observer location using two rounds are the same as those discussed in paragraph 12-29 except the predicted grid locations of the rounds are

used instead of known points. Information transmitted to the observer is the observer grid location and the azimuth measured to the first round.

**12-32. Observer Location Using Illumination Rounds and Second Observer With Known Location**

a. During periods of poor visibility, two illumination rounds are fired at the

observer's request. Both observers laser these rounds and report the data obtained to each round.

b. The FDC polar plots the location of the rounds from the known location of observer 2. Since the rounds were lasered by both observers at the same time, the locations determined by observer 2 establish two known points for observer 1 and are used to determine his location as stated in paragraph 12-29.

## ★ Section VIII. COMPUTER SET, FIELD ARTILLERY, GENERAL

The computer set, field artillery, general (hand-held calculator), supplements the existing FADAC/manual fire direction system by simplifying gunnery computation procedures. It is not intended to replace current manual or FADAC computation procedures, but, in a limited capacity, it supplements these procedures. When the use of FADAC in solving concurrent/subsequent met applications and HB/MPI registration procedures are not feasible (e.g., movement, lone gun operations, hip shoots), the hand-held calculator could be used.

**12-33. Capabilities**

The exact capabilities vary with different weapon systems. Listed below are those capabilities common to all weapon systems:

*a. Cannon Gunnery Application.*

(1) Determines gun-target azimuth and range to targets located by grid, shift from a known point, or polar method of target location.

(2) Determines M564 fuze settings for low angle fires and time of flight for high angle fires.

(3) Determines chart deflection, applied drift, and GFT deflection corrections and displays the deflection to fire.

(4) Determines elevation; applies angle of site, registration corrections, and 20/R; and displays quadrant elevation.

(5) Selects the lowest charge to fire.

(6) Applies subsequent corrections for range and deviation and computes subsequent firing data.

(7) Stores and applies registration corrections.

(8) Provides TFT/GFT entry arguments for computing firing data for illumination, APICM, DPICM, and FASCAM projectiles.

(9) Stores and recalls target locations.

(10) Computes angle T.

*b. High Burst/Mean Point of Impact Registration Applications.*

(1) Determines observer's orienting data.

(2) Averages observer's measured directions/vertical angles and determines the mean burst location grid and altitude.

*c. Terrain Gun Position/Special Corrections.*

(1) Determines piece displacement by the hasty traverse method.

(2) Determines lateral corrections to assigned sheaf burst lines.

*d. Concurrent Met Application.* Determines position deflection correction, position velocity error, and position fuze correction.

*e. Subsequent Met Application.* Determines total deflection correction, total range correction, and total fuze correction.

## 12-34. Limitations

The calculator uses a volatile memory. Therefore, it requires a continual power source. The calculator cannot:

- a. Store fire support coordination measures.
- b. Derive muzzle velocities.
- c. Compute chronograph/velocimeter reduction.
- d. Replot.
- e. Compute maximum ordinate.
- f. Compute complementary angle of site.

# ★ Section IX. ROCKET-ASSISTED PROJECTILE

## 12-35. Characteristics and Employment

a. Rocket-assisted projectiles (RAP) are available for the 155-mm and 8-inch howitzers only, and are used for fragmentation and blast effects against personnel and materiel. The rocket-on mode extends the range and improves the effectiveness of the weapon systems which use it. The 8-inch and 155-mm RAP computation procedures are identical.

b. The M549A1/M549 (RAP) is fired with charges 7 and 8 for M109A1/A2/A3 and 7, 8, and 8S for M198. Conventional HE rounds are used at shorter ranges. Since most missions are expected to be FFE missions, current GFT settings should always be used. When developing GFT settings, remember that corrections determined for ranges close to the maximum or minimum range for a charge are not as reliable as those at center ranges.

c. When no met or registration data is available, a GFT setting should be developed from the average battery VE, current powder temperature, and rocket motor propellant temperature.

## 12-36. Manual Solution Using GFT and TFT

The manual procedures for computing firing data are identical to those for shell HE M107. The HE M549A1 GFT and GST are read in the same manner as the HE M107 GFT and GST with one exception: There is no fuze setting scale. Data is determined as follows:

a. *Chart Data.* Chart range, deflection, and site are determined in the normal manner.

b. *Position Constants.*

(1) Complete the met data correction sheet by the procedures listed in chapter 6 through computation of the MET RANGE CORRECTION block.

(2) Enter table E.1 of TFT, CHG BR (M119A1), with entry range expressed to nearest listed range and rocket motor propellant temperature to nearest listed value. Rocket motor temperature is assumed to be the same as the propellant temperature.

(3) Extract the propellant temperature (rocket motor) range correction from table E.1.

PROPELLANT TEMP (ROCKET MOTOR)  
RG CORR (FROM TABLE E.1)

TOT RG CORR (FROM REGISTRATION)

The rocket motor propellant temp is assumed to be the same as propellant temp

MET RG CORR (FROM CONCURRENT MET)

| COMPUTATION OF VE   |                               |           |                             | PROPELLANT TEMP<br>ROCKET MOTOR RG CORR | -27  |
|---------------------|-------------------------------|-----------|-----------------------------|-----------------------------------------|------|
| PROP<br>TEMP +81 °F | VE                            | +14.9 M/S | +31.8                       | TOTAL RANGE<br>CORRECTION               | -660 |
|                     | CHANGE TO MV<br>FOR PROP TEMP | +2.5 M/S  | -31.4                       | MET RANGE<br>CORRECTION                 | -87  |
|                     | ΔV                            | +17.4 M/S | MV UNIT -31.4<br>CORRECTION | ΔV RANGE<br>CORRECTION                  | -546 |
|                     |                               |           |                             | TOTAL RANGE<br>CORRECTION               |      |

OLD VE \_\_\_\_\_ + NEW VE \_\_\_\_\_ = \_\_\_\_\_ +2 = AVG VE \_\_\_\_\_ M/S

Figure 12-16. Computation of ΔV range correction.

(4) Determine ΔV range correction by algebraically subtracting both the propellant temperature (rocket motor) range correction and the met range correction from the total range correction (fig 12-16).

(5) Compute the position velocity error in the same manner as in chapter 6.

*c. Firing Data Using the GFT.*

(1) *Fuze setting.* When firing fuze VT, the fuze setting is determined by dropping the tenths from the time of flight.

(2) *Deflection.* The piece deflection is determined by adding the drift correction to the GFT deflection correction corresponding to the elevation. The total deflection correction is applied to the chart deflection.

(3) *Quadrant elevation.* The quadrant elevation is determined by placing the MHL of the GFT over the chart range and reading the elevation under the elevation gageline. Apply site to the elevation to determine quadrant elevation.

*d. Firing Data Using Met to Target.* If no registration data is available, a met to target using a position deflection correction of zero and an inferred position VE from calibration (M90 velocimeter) or the average position VE brought forward from a previous position produces better firing data than no data (cold stick). A GFT setting can be derived from that

data and is usable within normal transfer limits until more accurate data becomes available. The example in the following paragraph, using met to target procedures, shows this.

**12-37. Example of GFT/TFT Fire for Effect**

The following problem illustrates the procedures for firing the RAP. Although the M549A1 projectile and firing tables prepared for the M109A1 howitzer are used in this example, these procedures apply for all weapons firing RAP.

*a. Known Data for M109A1 Howitzer.*

LOT M is propelling charge M4A2  
 LOT P is shell rocket assist M529A1  
 ALTITUDE OF BATTERY 516  
 LATITUDE 34° N  
 AZIMUTH OF LAY 6100  
 COMMON DEFLECTION 3200  
 KNOWN WEAPON MUZZLE  
 VELOCITY VARIATION -9.3 mps  
 PROJECTILE WEIGHT 3 □  
 POWDER TEMPERATURE +90° F  
 SITE +4  
 POSITION VELOCITY ERROR -8.7

*b. Target Data.*

CHARGE            7R (M109A1) (R indicates  
rocket-on)

ALTITUDE  
OF TARGET        584 meters

*c. Current Met Message.*

|        |     |     |
|--------|-----|-----|
| METB31 | 344 | 983 |
| 121430 | 037 | 013 |
| 002109 | 945 | 071 |
| 012212 | 937 | 079 |

|        |     |     |
|--------|-----|-----|
| -----  |     |     |
| 062822 | 949 | 065 |
| 073123 | 960 | 051 |

*d. Situation.* The following call for fire has been received in the FDC:

**P36 THIS IS P48, FIRE FOR  
EFFECT, OVER.**

**GRID 64213682, OVER.**

**COMPANY ADVANCING WITH  
MOTOR VEHICLES, OVER.**

*e. Situation Continued.*

(1) Fire Order: **FIRE FOR EFFECT,  
ROCKET ASSIST  
PROJECTILE,  
LOT MP, CHG 7R, 2  
ROUNDS.**

(2) HCO Data: **BRAVO RANGE  
16450, DEFLEC-  
TION 3184.**

(3) VCO Data: **SITE BRAVO +4.**

(4) Initial Fire Commands: **BTRY 2  
ROUNDS, SHELL,  
ROCKET ASSIST,  
LOT MP, CHG 7R\*.**

\*7R = Charge 7 with rocket on

*f. Determination of Corrected Data.*

(1) Enter table B of RAP TFT to extract line number and complementary range correction. Entry argument is chart range

# C1, FM 6-40

expressed to nearest 100 meters and height of target above gun expressed to nearest 100 meters.

(2) Compute met data correction as shown in figure 12-17.

## g. Determination of Firing Data.

(1) CHT DF (3184) + TOT DF CORR (L13)  
= DF TO FIRE (3197)

(2) CHT RG (16450) + TOT RG CORR (+150) = CORR RG (16600)

(3) EL ~ RG (16600) = 517

+ SITE

+ 4

QE TO FIRE

521

| MET DATA CORRECTION SHEET                                      |              |                            |                          |                  |                        |                      |            |                 |             |
|----------------------------------------------------------------|--------------|----------------------------|--------------------------|------------------|------------------------|----------------------|------------|-----------------|-------------|
| For use of this form, see FM 6-40; proponent agency is TRADOC. |              |                            |                          |                  |                        |                      |            |                 |             |
| BATTERY DATA                                                   |              |                            |                          |                  | MET MESSAGE            |                      |            |                 |             |
| CHARGE                                                         | ADJ QE       | CHART RG                   | LATITUDE                 | TYPE MESSAGE     | DATE                   | TIME                 | ALT MDP    | PRESSURE        | AREA/UNIT   |
| 7R                                                             |              | 16450                      | 30°N                     | MET 83           | 12                     | 1430                 | 370        | 101.3           | 344983      |
| ALT OF BTRY (10 m)                                             |              | 520                        |                          | LINE NO.         |                        | WIND DIR             | WIND SPEED | AIR TEMP        | AIR DENSITY |
| ALT OF MDP                                                     |              | 370                        |                          | 06               |                        | 2800                 | 22         | 94.9            | 106.5       |
| BTRY ABOVE/BELOW TOP (AN)                                      |              | 150                        |                          | A & B CORRECTION |                        | 0.3                  |            | 0.15            |             |
| ALT OF TARGET (nearest meter)                                  |              | 584                        |                          | CORRECTED VALUES |                        | 94.6                 |            | 105.0           |             |
| HEIGHT OF BURST ABOVE TARGET                                   |              |                            |                          |                  |                        |                      |            |                 |             |
| ALT OF BURST                                                   |              | 584                        |                          |                  |                        |                      |            |                 |             |
| ALT OF BTRY (nearest meter)                                    |              | 516                        |                          |                  |                        |                      |            |                 |             |
| HEIGHT OF TARGET (Burst) ABOVE GUN (M)                         |              | +68 ~ +100                 |                          | COMP RG          | +14                    | CHART RG             | 16450      | ENTRY RG        | 16464       |
|                                                                |              |                            |                          |                  |                        |                      |            | 16500           |             |
| WIND COMPONENTS AND DEFLECTION                                 |              |                            |                          |                  |                        |                      |            |                 |             |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD               |              | 6400                       |                          | POS DF CORR 0    |                        |                      |            |                 |             |
| DIRECTION OF WIND                                              |              | 2800                       |                          | MET DF CORR L13  |                        |                      |            |                 |             |
|                                                                |              | 9200                       |                          | TOT DF CORR L13  |                        |                      |            |                 |             |
| DIRECTION OF FIRE (WIND)                                       |              | 6120                       |                          | ROTATION CORR    |                        | 0.1                  |            |                 |             |
| CHART DIRECTION OF WIND                                        |              | 3080                       |                          | DRIFT CORR       |                        | 012.7                |            |                 |             |
| CROSS WIND                                                     | WIND SPEED   | 22                         | * COMP                   | 0.10             | 0.2                    | KNOTS                | 0.48       | CROSS WIND CORR | 0.10        |
| RANGE WIND                                                     | WIND SPEED   | 22                         | * COMP                   | 0.99             | 22                     | KNOTS                | 22         | MET DEFL CORR   | 12.8        |
|                                                                |              |                            |                          |                  |                        |                      |            | L13             |             |
| MET RANGE CORRECTION                                           |              |                            |                          |                  |                        |                      |            |                 |             |
|                                                                | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                   | MINUS                |            |                 |             |
| RANGE WIND                                                     | 22           | 0                          | 22                       | -16.5            | 363.0                  |                      |            |                 |             |
| AIR TEMP                                                       | 94.6         | 100%                       | 5.4                      | +1.6             | 8.6                    |                      |            |                 |             |
| AIR DENSITY                                                    | 105.0        | 100%                       | 5.0                      | +72.4            | 362.0                  |                      |            |                 |             |
| PROJ WEIGHT                                                    | 30           | 40                         | 10                       | -40              | 40.0                   |                      |            |                 |             |
| ROTATION                                                       |              | +11 x                      | 1.87                     | 9.6              | 403.0                  |                      |            |                 |             |
|                                                                |              |                            |                          |                  | 380.2                  | 403.0                |            |                 |             |
|                                                                |              |                            |                          |                  | 380.2                  | 403.0                |            |                 |             |
|                                                                |              |                            |                          |                  | 22.8                   | -23                  |            |                 |             |
| COMPUTATION OF VE                                              |              |                            |                          |                  |                        |                      |            |                 |             |
| VE                                                             |              | -8.7                       | M/S                      | +30.8            | TOTAL RANGE CORRECTION |                      |            |                 |             |
| PROP TEMP                                                      | +90          | CHANGE TO MV FOR PROP TEMP | +1.8                     | M/S              | -30.2                  | MET RANGE CORRECTION |            |                 |             |
|                                                                | SV           | -6.9                       | M/S                      | +30.8            | AV RANGE CORRECTION    | +232                 |            |                 |             |
|                                                                |              |                            |                          |                  | TOTAL RANGE CORRECTION | +166                 |            |                 |             |
| OLD VE                                                         |              |                            |                          |                  |                        |                      |            |                 |             |
| MET FUZE CORRECTION                                            |              |                            |                          |                  |                        |                      |            |                 |             |

Figure 12-17. Met data correction (RAP).



# CHAPTER 13

## NUCLEAR GUNNERY

### Section I. 8-INCH NUCLEAR DELIVERY

Among the US Army weapons capable of delivering nuclear rounds are the 8-inch howitzers, both towed and self-propelled. The nuclear techniques involved with the 8-inch system are identical to the conventional delivery techniques except for the addition of ballistic corrections for the nuclear round. The 8-inch system has two ballistically similar rounds that are used in the computation of firing data. They are the high explosive spotting (HES) round M424A1 and the nuclear round M422A1. The HES round is used for registrations and adjustments while the nuclear (nuc) round is used to fire for effect. Both projectiles have a standard weight of 242 pounds. The M424A1 (HES) is armed by a mechanical timer (M591), and the M422A1 (nuc) is armed by the M542 or T316E3 time fuze. All data is computed using the FT-8-R-1 and GFT and GST 8-R-1.

★ *Note.* If the unit has only two HES (M424A1) rounds, a two-round HB registration is allowable. However, the commander must weight the loss of accuracy (see table 5-1). The three-round method is still the preferred technique.

#### 13-1. Delivery Techniques

There are three delivery techniques that can be used: *K-transfer*, *met + VE*, and *observer adjustment*. Regardless of the technique used, all data is determined to the same accuracy required in standard gunnery procedures.

*a. K-Transfer.* The K-transfer technique uses registration corrections from an HES registration to determine data for the nuclear round. The HES data is modified to correct for ballistic differences, propellant temperature differences, and weight differences between the HES and nuclear rounds.

(1) *Requirements.* To use this technique, a valid GFT setting from an HES registration must be available. Normally, an HES HB registration is conducted. The target must be accurately located and be within transfer limits.

(2) *Accuracy.* The accuracy of K-transfer technique is dependent upon the validity of the GFT setting. As the time since the HES registration increases, the validity of the GFT setting decreases. Sudden changes in weather will invalidate the GFT setting.

(3) *Speed.* The K-transfer technique is the fastest method of determining firing data.

*b. Met + VE.* When an HES HB registration is conducted, a concurrent met should be solved. The resulting position constants can be used with a met to determine data by solving a met to the target.

★ (1) *Requirements.* To use this technique, the target must be accurately located and valid position constants available. A current met message is also required. The

requirements regarding position constants are different from conventional requirements. Position velocity error includes deviations from standard in the weapon and ammunition and errors in the firing chart, met message, and survey data. For conventional ammunition, the position VE is valid only for the position, weapon, charge, and propellant for which it was determined. However, with nuclear delivery the manufacturer's tolerances are more exacting for the spotting and nuclear rounds. In addition, nuclear delivery units will probably have a higher survey and met priority than other units. Accordingly, the position VE is continually averaged at every opportunity. Judgment must be used in the continual averaging of these position VEs. If a large deviation of a new position VE from the average occurs, the error should be isolated. If the reason cannot be determined, it is usually better to omit the new position VE when the average VE is being computed. Position fuze constant can also be averaged continually and used from one position to another. The position deflection constant can also be averaged and carried forward if common directional control exists between all positions. The position deflection constant should not be used in a new location if common directional control does not exist.

- ★ (2) *Accuracy.* When the position VE for the M424 projectile is available, the met + VE technique is accurate. When registration data is not current or the target is outside or on the fringes of transfer limits, this technique is preferred. The accuracy depends upon a current met message.

(3) *Speed.* The met + VE solution is slower than the K-transfer technique as it requires the solution of a met.

*c. Observer Adjustment.* The observer adjustment technique requires the observer to adjust onto the target with the HES projectile, then firing the nuclear round in fire for effect.

(1) *Requirements.* This technique requires an observer in position to observe the

target. The observer must adjust range, deviation, and height of burst simultaneously.

(2) *Accuracy.* The accuracy will depend upon the observer's ability to adjust onto the target accurately.

(3) *Speed.* The speed with which this mission can be accomplished depends upon the observer's speed and ability. Usually, it will be the slowest technique.

#### ★ 13-2. Registration and Determination of a GFT Setting

It is anticipated that in a nuclear environment, the unit will conduct a two-round high burst registration with shell HES for at least one weapon from a selected firing point. This registration will yield a GFT setting for the K-transfer technique. A met solved concurrent with the registration will establish a position VE, position df correction, and position fuze correction to be used in the met + VE technique. The registration should be conducted as soon as possible after occupation of position and should not be delayed until the receipt of a nuclear mission. The following example illustrates an HES registration.

##### *Example:*

(1) The S3 of an 8-inch battalion with a general support mission has directed that Battery B conduct a two-round high burst registration with one of their weapons. The following fire order and initial fire command are announced:

**NUMBER 1, HIGH BURST REGISTRATION: GRID 6640, HEIGHT OF BURST 140, USE GFT, SHELL HES, LOT ROMEO ZULU, CHARGE 3, FUZE TIME, AT MY COMMAND.**

**NUMBER 1, ADJUST, AT MY COMMAND, SHELL HES, LOT ROMEO ZULU, CHARGE 3, FUZE TIME.**

(2) With only two rounds to be fired, it is imperative that all rounds be observed accurately. Therefore, the firing data must reflect corrections for as many of the known nonstandard conditions as possible. Any known average weapon position VE and fuze correction for shell HES should be applied to current met data. These corrections are combined in solving a met to the orienting point. In this example, a position deflection correction is not available.

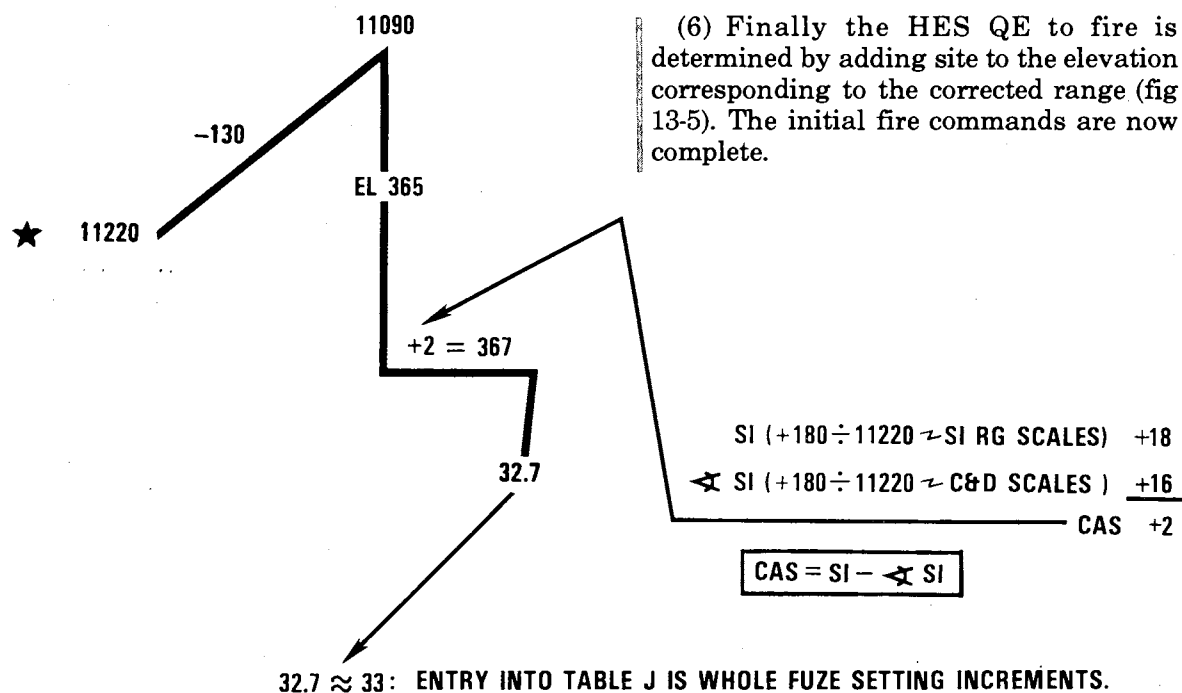
(3) A met to the orienting point with computations through total range correction is shown in figure 13-1.

(4) To determine total fuze correction, enter table J of the TFT. The argument of entry is fuze setting (FS) corresponding to el + CAS. (HOB required will yield a large VI, which must be considered.) To determine FS, add the total range correction (from met) to the chart range. Move the MHL over this corrected range and determine a corresponding el. Compute site (divide the VI by the chart range using site/range scales in the appropriate GST). Compute angle of site (VI divided by chart range using C and D scales). Subtract angle of site from site obtaining CAS. Add CAS to the el corresponding to the corrected range determined above. Move MHL over this value and determine (under MHL) the FS corresponding to el + CAS. To facilitate these computations, a modification of the "lazy Z" can be used (fig 13-2). Entering table J with an FS of 33, the total fuze correction is computed (fig 13-3). By applying the total fuze correction to the FS corresponding to el + CAS, the HES FS to fire will be 32.6.

(5) A position deflection correction was not available for this met. Therefore, the position deflection correction is 0 and when applied to a met df correction of R2, the total deflection correction will be R2. The df to fire is 3146 (fig 13-4).

| MET DATA CORRECTION SHEET                                      |                 |                          |                  |              |             |        |       |       |  |
|----------------------------------------------------------------|-----------------|--------------------------|------------------|--------------|-------------|--------|-------|-------|--|
| For use of this form, see FM 6-40; proponent agency is TRADOC. |                 |                          |                  |              |             |        |       |       |  |
| BATTERY DATA                                                   |                 |                          |                  |              | MET MESSAGE |        |       |       |  |
| CHARGE                                                         | ADJ. Q          | COUNT NO.                | LATITUDE         | FIRE MESSAGE | REMARKS     |        |       |       |  |
| 3                                                              |                 | 11220                    | 30N              | METR3        | 1           | 987351 |       |       |  |
| ALT. OF BTRY (10m)                                             |                 | 360                      |                  | 25           | 1400        | 350    | 99.2  |       |  |
| ALT. OF MFL                                                    |                 | 350                      |                  | 04           | 2900        | 22     | 100.2 | 98.1  |  |
| ST. CHART RANG. (M)                                            |                 | 10                       |                  |              |             |        | 0.00  | 0.1   |  |
| ALT. OF TARGET (meters)                                        |                 | 405                      |                  |              |             |        | 100.2 | 98.0  |  |
| HEIGHT OF BURST ABOVE TARGET                                   |                 | 140                      |                  |              |             |        |       |       |  |
| ALT. OF BURST                                                  |                 | 545                      |                  |              |             |        |       |       |  |
| ALT. OF BTRY (meters)                                          |                 | 365                      |                  |              |             |        |       |       |  |
| HEIGHT OF TARGET (meters) ABOVE GUN                            |                 | +180                     |                  | +34          |             |        |       |       |  |
|                                                                |                 | 11220                    |                  | 11254        |             |        |       | 11300 |  |
| WIND COMPONENTS AND DEFLECTION                                 |                 |                          |                  |              |             |        |       |       |  |
| WIND DIRECTION OF WIND IS LESS THAN ON FIRE ADD                |                 |                          |                  | POS+MET=TOT  |             |        |       |       |  |
| DIRECTION OF WIND                                              |                 | 2900                     |                  | 0 + R2 = R2  |             |        |       |       |  |
| DIRECTION OF FIRE                                              |                 | 900                      |                  |              |             |        |       |       |  |
| CHART DIRECTION OF WIND                                        |                 | 2000                     |                  |              |             |        |       |       |  |
| CROSS WIND SPEED                                               |                 | 22                       |                  | 0.38         |             |        |       |       |  |
| RANGE WIND SPEED                                               |                 | 22                       |                  | 0.38         |             |        |       |       |  |
| NET RANGE CORRECTION                                           |                 |                          |                  |              |             |        |       |       |  |
| KNOWN VALUES                                                   | STANDARD VALUES | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS         | MINUS       |        |       |       |  |
| RANGE WIND                                                     | 8               | 0                        | -10.7            |              | 85.6        |        |       |       |  |
| AIR TEMP                                                       | 100.2           | 0.2                      | -9.2             |              | 1.8         |        |       |       |  |
| AIR DENSITY                                                    | 98.0            | 2.0                      | -43.0            |              | 86.0        |        |       |       |  |
| PROJ. HEIGHT                                                   | 244             | 242                      | +5               | 10.0         | 24.4        |        |       |       |  |
| ROTATION                                                       |                 | -28                      | 8.87             |              | 10.0        | 197.8  |       |       |  |
|                                                                |                 |                          |                  |              |             | 10.0   |       |       |  |
|                                                                |                 |                          |                  |              |             | 187.8  | -188  |       |  |
| COMPUTATION OF VE                                              |                 |                          |                  |              |             |        |       |       |  |
| POS                                                            | VE              | -1.4                     |                  | 0+23.3       |             |        |       |       |  |
| CHANGE TO VE FOR PROJ. TEMP                                    |                 | -1.1                     |                  | I-22.9       |             |        |       |       |  |
| SV                                                             |                 | -2.5                     |                  | 0+23.3       |             |        |       |       |  |
|                                                                |                 |                          |                  |              |             |        |       |       |  |
| NET FUZE CORRECTION                                            |                 |                          |                  |              |             |        |       |       |  |
| FS-EL+CAS                                                      |                 | 32.7                     |                  | 33           |             |        |       |       |  |
| AV                                                             |                 | 2.5                      | -0.044           |              | 0.110       |        |       |       |  |
| RANGE WIND                                                     |                 | 8                        | +0.005           | 0.040        |             |        |       |       |  |
| AIR TEMP                                                       |                 | 0.2                      | -0.003           |              | 0.001       |        |       |       |  |
| AIR DENSITY                                                    |                 | 2.0                      | +0.058           | 0.116        |             |        |       |       |  |
| PROJ. HEIGHT                                                   |                 | 244                      | -0.020           |              | 0.040       |        |       |       |  |
|                                                                |                 |                          |                  |              | 0.151       |        |       |       |  |
|                                                                |                 |                          |                  |              | 0.005       |        |       |       |  |
| NET FUZE CORN                                                  |                 |                          |                  |              |             |        |       |       |  |
| OLD FUZE CORN                                                  |                 |                          |                  |              |             |        |       |       |  |
| TARGET NO                                                      |                 |                          |                  |              |             |        |       |       |  |
| DA FORM 4200 REPLACES DA FORM 6 15, 1 APR 67 WHICH IS OBSOLETE |                 |                          |                  |              |             |        |       |       |  |

Figure 13-1. Met to the orienting point.



**Figure 13-2. Modified lazy Z.**

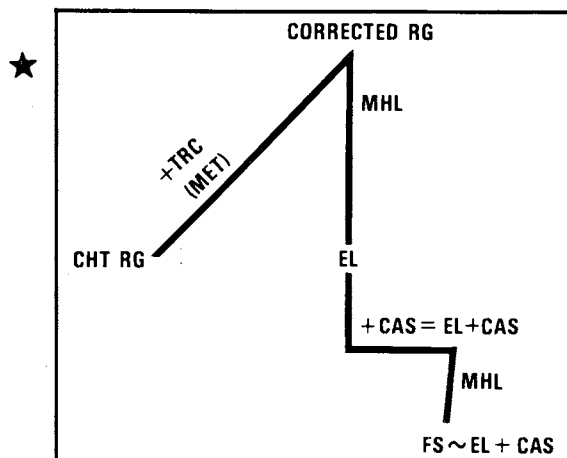


Figure 13-3. Computation of the total fuze correction.

| RECORD OF FIRE                                            |  |              |           |                                                                                   |          |             |  |               |  |               |  |
|-----------------------------------------------------------|--|--------------|-----------|-----------------------------------------------------------------------------------|----------|-------------|--|---------------|--|---------------|--|
| _____ Tgt _____<br>_____ VA _____<br>-+/- _____ U/D _____ |  |              |           | GRID ALT 405<br>WPN ALT 365<br>_____<br>_____ (FROM MET)<br>* Si ÷ 10      10m Si |          |             |  |               |  |               |  |
| HES LOT RZ CHG3 FZ TI AMC                                 |  |              |           |                                                                                   |          |             |  | Df Corr R2    |  |               |  |
| _____ Rg 11220                                            |  |              |           | Chr Df 3148                                                                       |          |             |  |               |  |               |  |
| Sh _____                                                  |  | Lot RZ _____ |           | Chg 3 _____                                                                       |          | Fz T1 _____ |  | Ti 32.6 _____ |  | Df 3146 _____ |  |
| * T _____                                                 |  |              | PER _____ |                                                                                   | TF _____ |             |  | in Eff _____  |  |               |  |

Figure 13-4. Computation of deflection.

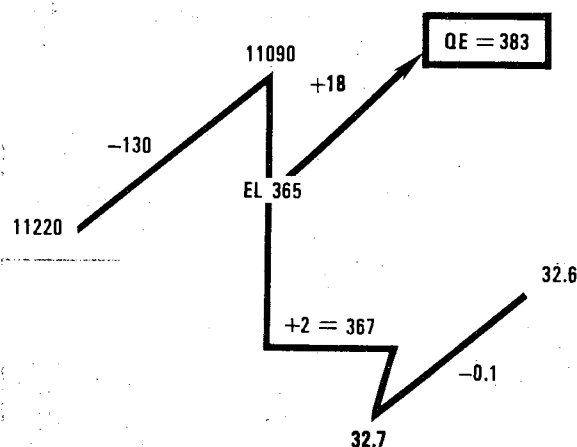


Figure 13-5. Determination of HES QE to fire.

### Determining the GFT Setting.

(1) Once the high burst has been fired, the mean burst location is plotted and chart data determined (fig 13-6).

| COMPUTATION OF GFT SETTING |     |          |        |                                  |       |
|----------------------------|-----|----------|--------|----------------------------------|-------|
| Alt HB (MPS)               | 522 | QE fired | 383    | Chart data Alt HB (MPS) location | 11240 |
| Alt Btry                   | 365 | Site     | -(+16) | GFT 1 Charge                     | RZ    |
| VI                         | 157 | Adj Elev | 367    | Range                            | 11240 |
| DA FORM 4201               |     |          |        |                                  |       |

Figure 13-6. Determination of chart data.

(2) Using the data above, the GFT setting can be computed.

Site =  $+16 (+157 \div 11240 \text{ site range scales})$

$\Delta$  Site =  $+14 (+157 \div 11240 \text{ C and D scales})$

CAS +2

(3) The large VI requires the consideration of CAS in the determination of a total fuze correction and consequently an adjusted time. The steps are similar to those used to compute firing data for the high burst. A total fuze correction of -0.3 is determined by comparing the FS~el + CAS with the FS fired (fig 13-7). The total fuze correction is then applied to the FS~adj el in order to determine an adjusted time that does not include the effects of complementary angle of site.

(4) The GFT deflection correction is computed in the same manner as in conventional gunnery procedures.

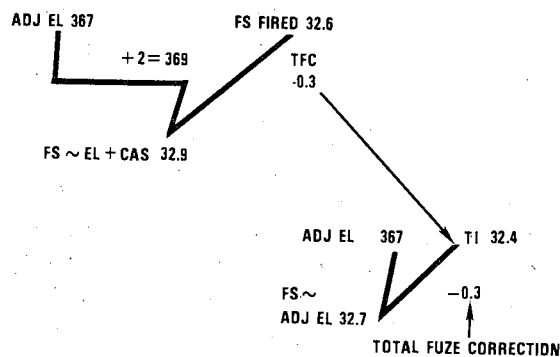


Figure 13-7. Total fuze correction.

Cht  
df 3140  $\longrightarrow$  adj df 3146 = total df corr L6  
-drift~el 367 - (L8)  
GFT df corr R2

The completed computation of the GFT setting is:

GFT 1: Chg 3, Lot RZ, Rg 11240, El 367, Ti 32.4.

GFT Df Corr: R2.

This GFT setting can now be used in the K-transfer technique as long as weather conditions remain stable and the target is within transfer limits.

*Note.* This GFT setting should be updated with subsequent mets when deemed necessary by the FDO.

Position constants are determined by the solution of a concurrent met (figure 13-8) using the 8-R-1 TFT. The newly determined constants are averaged with previously determined M424A1 constants in a manner identical to HE procedure.

### 13-3. K-Transfer Technique

a. The K-transfer technique requires the use of the GFT setting and GFT deflection correction determined from the high burst registration. The GFT setting determined in paragraph 13-2 will be used in this example.

b. The K-transfer technique requires the application of differences between HES and nuclear projectile weights and propellant temperatures and the determination of

ballistic corrections. The ballistic corrections for the nuclear round are applied to the final fuze setting, deflection, and QE computed for the HES round.

c. Usually the target information will be sent to the unit from higher headquarters. Normally, this data will be classified, but it

must include a grid location and altitude and the desired HOB.

*d.* The grid of the target must be plotted on the chart and a range and deflection recorded on the record of fire. The FDO must make a decision as to which technique to use to determine firing data. This target is within

DA FORM 4200 REPLACES DA FORM 6-15, 1 APR 67, WHICH IS OBSOLETE  
JAN 74 \*U.S. G.P.O. 1977-765037/45

Figure 13-8. Determination of position constants.

transfer limits of the high burst location and the GFT setting is still valid; therefore, the K-transfer technique will be used. Fire order and initial fire commands are:

NUMBER 1, USE GFT, SHELL NUC  
LOT TANGO ZULU, CHARGE 3  
FUZE TIME, HEIGHT OF BURST 180,  
AT MY COMMAND  
NUMBER 1, ONE ROUND AT MY  
COMMAND, SHELL NUC, LOT  
TANGO ZULU, CHARGE 3, FUZE  
TIME.

e. The computer needs the projectile weight and propellant temperature of the HES round used in the registration, and the weight and propellant temperature of the nuclear projectile at the time the mission is being computed.

#### Projectile Weights

HES: 244  
Nuc: 240

#### Propellant Temperatures

HES: +64  
Nuc: +74

The differences in projectile weights and propellant temperatures must be determined and a corresponding range correction in meters applied to the chart range. The result is a corrected range at which the firing data will be computed.

f. The 8-Inch Nuclear Computation, DA Form 4207 (K-transfer column) will be used.

(1) *Determination of entry range, blocks 1-8 (fig 13-9).* An entry range is necessary to determine unit corrections for projectile weight and propellant temperature.

*Note.* This is the same procedure used to find a met entry range.

| K-TRANSFER |                                  |          |       |
|------------|----------------------------------|----------|-------|
| 1          | Alt of Tgt                       | (1M)     | 341   |
| 2          | HOB Above Tgt                    | (1M)     | 180   |
| 3          | Alt of Burst (1 plus 2)          | (1M)     | 521   |
| 4          | Alt of Btry                      | (1M)     | 365   |
| 5          | HOB Above Gun (3 minus 4)        | (1M)     | 156   |
| 6          | Chart Rg to Tgt                  | (10M)    | 10460 |
| 7          | Comp Rg (Tbl B)                  | (1M)     | +30   |
| 8          | Entry Rg (6 plus 7) [10490 (1m)] | ≈ (100M) | 10500 |

Figure 13-9. Determination of entry range.

(2) *Determination of corrections for difference in projectile weight and propellant temperature, blocks 9-19 (fig 13-10).*

(a) *Propellant temperature.* The first step is to determine the change to MV for the change in propellant temperature.

ΔMV for nuc propellant temperature (enter table E with +74° F.) +0.7

ΔMV for HES propellant temperature (enter table E with +64° F.) -1.1

The difference (increase or decrease) between the MV must be determined by going from the HES propellant temperature to the nuc propellant temperature (-1.1 m/s → +0.7 m/s) = increase 1.8 m/s. The unit correction factor (table F at entry range 10,500 and col 11 with increase) is -22.1 m/s. The correction in meters for the change in propellant temperature is determined by multiplying 1.8 × -22.1 = -39.78 ≈ -40.

|    |                                    |                      |       |
|----|------------------------------------|----------------------|-------|
| 9  | Δ MV (Tbl E) [ NUC PT ( 74 °F ) ]  | (0.1M/S)             | +0.7  |
| 10 | Δ MV (Tbl E) [ Spot PT ( 64 °F ) ] | (0.1M/S)             | -1.1  |
| 11 | Difference (9 minus 10)            | (0.1) <del>0.0</del> | 1.8   |
| 12 | Unit Corr (Tbl F, Col 10/11)       | (0.1)                | -22.1 |
| 13 | Corr for Prop Temp (11 X 12)       | (1M)                 | -40   |

Figure 13-10. Corrections for differences in projectile weight.

(b) *Projectile weight (fig 13-11).*

*Difference in weight*

HES → nuc (244 → 240 = dec 4 lb)  
decrease 4 pounds.

Unit correction (table F at entry range 10,500 and column 18 with decrease) . . . -5 meters  
Correction in meters for change in weight is (4 × -5 meters = -20 meters).

|    |                              |                      |     |
|----|------------------------------|----------------------|-----|
| 14 | NUC Wt                       | (1Lb)                | 240 |
| 15 | Spotter Wt                   | (1Lb)                | 244 |
| 16 | Difference (14 minus 15)     | (1Lb) <del>0.0</del> | 4   |
| 17 | Unit Corr (Tbl F, Col 18/19) | (1.0)                | -5  |
| 18 | Corr for Proj Wt (16 X 17)   | (1M)                 | -20 |

Figure 13-11. Corrections for projectile weight.

(c) *Corrected range.* The corrected range is determined by adding the corrections in meters for the weight and temperature to the initial chart range to

target and expressing the total to the same accuracy as chart range (10 meters):

Temperature correction ..... -40 meters  
Projectile (weight)

correction ..... +(-20 meters)

Initial chart range ..... 10460 meters

Corrected range ..... 10400 meters

The corrected range must be computed before any values on the GFT can be determined (fig 13-12).

$$19 \quad \text{Corrected Rg (E+13+18)} [10400 \quad (1m)] \approx (10M) [10400]$$

Figure 13-12. Corrected range.

(3) *Determination of HES quadrant elevation, blocks 20-23 (fig 13-13).* The HES QE is determined with the use of the current GFT setting. With the corrected range set off under the MHL on the GFT, an elevation is read under the El gageline (block 20). Site and angle of site are determined with the GST and entered in blocks 21 and 23, respectively. Site is added to elevation to determine HES QE (block 22).

|    |                                 |       |     |
|----|---------------------------------|-------|-----|
| 20 | El ~ 19 (HES GFT Setting)       | (1pt) | 321 |
| 21 | Site (GST, VI 5 At Rg 5)        | (1pt) | +17 |
| 22 | QE for Spotter (20 plus 21)     | (1pt) | 338 |
| 23 | Angle of Site (GST, C&D Scales) | (1pt) | +15 |

Figure 13-13. Determination of HES quadrant.

(4) *Determination of fuze setting, blocks 24-27 (fig 13-14).* The fuze setting to fire is the fuze setting corresponding to elevation plus comp site, plus the ballistic correction from table M of the TFT. El + CAS is determined in block 24 and placed under the elevation gageline. Fuze setting is read under the time gageline. The ballistic correction that needs to be applied to HES FS is found in table M of firing table 8-R-1 (fig 13-15). The entries into table M are the HES QE (338) to the nearest listed value and the HOB above weapon (+156) to the nearest listed value. The DDF to the nearest tenth (block 30) and DQE to the nearest mil (block 32) can be determined at this time so that the computer does not have to reenter table M when computing deflection and QE to fire. Normally, values can be visually interpolated.

|    |                                 |       |       |
|----|---------------------------------|-------|-------|
| 24 | El plus Comp Site (22 minus 23) | (1pt) | 323   |
| 25 | FS ~ 24 (HES GFT Setting)       | (0.1) | 29.1  |
| 26 | Bal Fz Corr for NUC (Tbl M)     | (0.1) | + 0.1 |
| 27 | FS to Fire (25 plus 26)         | (0.1) | 29.2  |

Figure 13-14. Determination of fuze setting.

CHANGE 5

TABLE M  
CORRECTIONS FOR  
PROJ. ATOMIC, M422A1

PT 8-R-1  
PROJ. HES, M424A1  
FUZE, MT, HS01

CORRECTIONS TO COMPENSATE FOR BALLISTIC DIFFERENCES  
BETWEEN PROJ. HES, M424A1 AND PROJ. ATOMIC, M422A1

| QUAD<br>ELPV<br>M424A1<br>MILS | HEIGHT OF BURST ABOVE GUN - METERS |                   |                   |                   |                   |                   |                   |                   |  |  |  |
|--------------------------------|------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|--|
|                                | -400                               | -300              | -200              | -100              | 0                 | 100               | 200               | 300               |  |  |  |
| 100                            | QF 2.6<br>FS 0.1<br>CD 0.4         | 2.6<br>0.1<br>0.4 | 2.6<br>0.1<br>0.4 | 2.5<br>0.1<br>0.4 | 2.5<br>0.1<br>0.4 | 2.4<br>0.1<br>0.4 | 2.4<br>0.1<br>0.4 | 2.3<br>0.1<br>0.4 |  |  |  |
| 110                            | QF 2.7<br>FS 0.1<br>CD 0.5         | 2.7<br>0.1<br>0.5 | 2.6<br>0.1<br>0.5 | 2.6<br>0.1<br>0.5 | 2.5<br>0.1<br>0.5 | 2.5<br>0.1<br>0.5 | 2.4<br>0.1<br>0.5 | 2.4<br>0.1<br>0.5 |  |  |  |
| 120                            | QF 2.7<br>FS 0.1<br>CD 0.5         | 2.7<br>0.1<br>0.5 | 2.7<br>0.1<br>0.5 | 2.6<br>0.1<br>0.5 | 2.5<br>0.1<br>0.5 | 2.5<br>0.1<br>0.5 | 2.4<br>0.1<br>0.5 | 2.4<br>0.1<br>0.5 |  |  |  |
| 130                            | QF 2.8<br>FS 0.1<br>CD 0.5         | 2.7<br>0.1<br>0.5 | 2.7<br>0.1<br>0.5 | 2.7<br>0.1<br>0.5 | 2.6<br>0.1<br>0.5 | 2.6<br>0.1<br>0.5 | 2.5<br>0.1<br>0.5 | 2.5<br>0.1<br>0.5 |  |  |  |
| 140                            | QF 2.8<br>FS 0.2<br>CD 0.5         | 2.8<br>0.2<br>0.5 | 2.8<br>0.2<br>0.5 | 2.7<br>0.2<br>0.5 | 2.7<br>0.2<br>0.5 | 2.6<br>0.2<br>0.5 | 2.6<br>0.2<br>0.5 | 2.5<br>0.2<br>0.5 |  |  |  |
| 150                            | QF 2.9<br>FS 0.2<br>CD 0.6         | 2.8<br>0.2<br>0.5 | 2.8<br>0.2<br>0.5 | 2.8<br>0.2<br>0.5 | 2.7<br>0.2<br>0.5 | 2.7<br>0.2<br>0.5 | 2.6<br>0.2<br>0.5 | 2.6<br>0.2<br>0.5 |  |  |  |
| 160                            | QF 2.9<br>FS 0.2<br>CD 0.6         | 2.9<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.7<br>0.2<br>0.6 | 2.7<br>0.2<br>0.6 | 2.6<br>0.2<br>0.6 | 2.6<br>0.2<br>0.6 |  |  |  |
| 170                            | QF 3.0<br>FS 0.2<br>CD 0.6         | 2.9<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.7<br>0.2<br>0.6 | 2.7<br>0.2<br>0.6 |  |  |  |
| 180                            | QF 3.0<br>FS 0.2<br>CD 0.6         | 3.0<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 |  |  |  |
| 190                            | QF 3.1<br>FS 0.2<br>CD 0.6         | 3.0<br>0.2<br>0.6 | 3.0<br>0.2<br>0.6 | 3.0<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.9<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 | 2.8<br>0.2<br>0.6 |  |  |  |
| 200                            | QF 3.1<br>FS 0.2<br>CD 0.7         | 3.1<br>0.2<br>0.7 | 3.0<br>0.2<br>0.7 | 3.0<br>0.2<br>0.7 | 3.0<br>0.2<br>0.7 | 2.9<br>0.2<br>0.7 | 2.9<br>0.2<br>0.7 | 2.9<br>0.2<br>0.7 |  |  |  |

Figure 13-15. Ballistic corrections (table M).

(5) *Determination of deflection to fire, blocks 28-31 (fig 13-16).* The deflection to fire is determined in the same way as conventional gunnery procedures with the addition of a ballistic correction from table M. The deflection correction and ballistic correction are added to the chart deflection as shown.

|    |                                                        |       |      |
|----|--------------------------------------------------------|-------|------|
| 28 | Chrt DF to Tgt                                         | (1pt) | 3132 |
| 29 | DF Corr [ GFT D1 <u>R2</u> + Drift ~ El 20 <u>L7</u> ] |       | L5   |
| 30 | Bal DF Corr for NUC (Tbl M) [ <u>R4</u> (0.1pt)]       |       | 0    |
| 31 | DF to Fire (28+29+30)                                  | (1pt) | 3137 |

Figure 13-16. Determination of deflection to fire.

(6) *Determination of the nuc QE, blocks 32-34 (fig 13-17).* The QE to fire is determined by applying the ballistic correction from table M (already known) to the HES QE (already computed). The fire commands are now complete.



|    |                             |       |     |
|----|-----------------------------|-------|-----|
| 32 | QE for Spotter, 22          | (1pt) | 338 |
| 33 | Bal QE Corr for NUC (Tbl M) | (1pt) | +3  |
| 34 | QE to Fire (32+33)          | (1pt) | 341 |

Figure 13-17. Determination of nuc QE.

### 13-4. Met + VE Technique

a. The computation of met + VE for nuclear missions is the same as that for shell HE except the fuze setting (use elevation plus comp site). As in the K-transfer technique, the ballistic difference between the spotting round and nuclear round must be applied using table M.

b. A message is received with target information for a nuclear mission. It included an HOB of 140 meters. The met + VE technique will be used.

c. To determine data to fire, a met to the target is solved using the position constants determined from the concurrent met in paragraph 13-2 (fig 13-18). The use of an inferred QE for entry into table A to determine a met line number is a matter of judgment. If the GFT setting is considered invalid, table B should be used to determine the met line number. If the QE can be reasonably inferred, that QE and table A may be used.

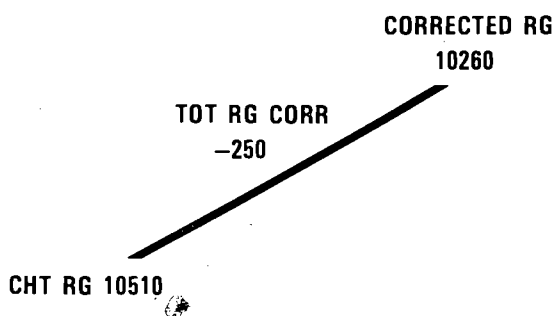
| MET DATA CORRECTION SHEET                                     |                            |                          |                          |                           |                        |            |                        |          |         |
|---------------------------------------------------------------|----------------------------|--------------------------|--------------------------|---------------------------|------------------------|------------|------------------------|----------|---------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |                            |                          |                          |                           |                        |            |                        |          |         |
| BATTERY DATA                                                  |                            |                          |                          |                           |                        |            |                        |          |         |
| CHARGE                                                        | 3                          | ADJ OF                   | 10510                    | 30°N                      | TYPE MESSAGE           | MET        | 83                     | OCTANT   | 1       |
| ALT OF BTRY (10m)                                             | 360                        | DATE                     | 26                       | TIME                      | 0730                   | ALT MDP    | 350                    | PRESSURE | 987.351 |
| ALT OF MDP                                                    | 350                        | LINE NO                  | 03                       | WIND DIR                  | 4200                   | WIND SPEED | 15                     | AIR TEMP | 99.6    |
| BTRY (ABOVE) MDP (10m)                                        | +10                        | AN CORRECTION            |                          |                           |                        | 102.0      | AIR DENSITY            | 98.2     |         |
| ALT OF TARGET (nearest meters)                                | 370                        | CORRECTED VALUES         |                          |                           |                        | 102.0      |                        | 98.1     |         |
| HEIGHT OF BURST ABOVE TARGET                                  | 140                        | LINE NUMBER FROM TABLE B |                          |                           |                        |            |                        |          |         |
| ALT OF BURST                                                  | 510                        |                          |                          |                           |                        |            |                        |          |         |
| ALT OF BTRY (nearest meters)                                  | 365                        |                          |                          |                           |                        |            |                        |          |         |
| HEIGHT OF TARGET (burst) ABOVE GUN (m)                        | +145                       | COMP RG                  | +14                      | CHART RG                  | 10510                  | ENTRY RG   | 10524                  | 10500    |         |
| WIND COMPONENTS AND DEFLECTION                                |                            |                          |                          |                           |                        |            |                        |          |         |
| WHEN DIRECTION OF WIND IS LESS THAN OUR FINE ADD              | 5400                       | TOT = MET + POS          |                          |                           |                        |            |                        |          |         |
| DIRECTION OF WIND                                             | 4200                       | L13 = L7 + L6            |                          |                           |                        |            |                        |          |         |
| DIRECTION OF FIRE                                             | 1200                       |                          |                          |                           |                        |            |                        |          |         |
| CHART DIRECTION OF WIND                                       | 3000                       |                          |                          |                           |                        |            |                        |          |         |
| CROSS WIND SPEED                                              | 15                         | COMP                     | 0.20                     | 3                         | KNOTS                  | 5          | UNIT CORR              |          |         |
| RANGE WIND SPEED                                              | 15                         | COMP                     | 0.98                     | 15                        | KNOTS                  |            | UNIT CORR              |          |         |
| MET RANGE CORRECTION                                          |                            |                          |                          |                           |                        |            |                        |          |         |
|                                                               | KNOWN VALUES               | STANDARD VALUES          | VARIATIONS FROM STANDARD | UNIT CORRECTIONS          | PLUS                   | MINUS      |                        |          |         |
| RANGE WIND                                                    | 15                         | 0                        | 15                       | -9.2                      |                        |            | 138.0                  |          |         |
| AIR TEMP                                                      | 102.0                      | 100%                     | 2.0                      | -6.8                      |                        |            | 13.6                   |          |         |
| AIR DENSITY                                                   | 98.1                       | 100%                     | 1.9                      | -39.2                     |                        |            | 74.5                   |          |         |
| PROJ WEIGHT                                                   | 240                        | 242                      | 2                        | -5                        |                        |            | 10.0                   |          |         |
| ROTATION                                                      | -36                        | 87                       |                          |                           |                        |            | 31.3                   |          |         |
|                                                               |                            |                          |                          |                           |                        |            | 267.4                  |          |         |
|                                                               |                            |                          |                          |                           |                        |            | 267.4                  | -267     |         |
| COMPUTATION OF VI                                             |                            |                          |                          |                           |                        |            |                        |          |         |
| PROP + 75                                                     | VI                         | -1.5                     | M S                      | 0 + 22.4                  | TOTAL RANGE CORRECTION |            |                        |          |         |
|                                                               | CHANGE TO MV FOR PROP TEMP | +0.9                     | M S                      | I - 22.1                  | MET RANGE CORRECTION   |            | -267                   |          |         |
|                                                               | ΔV                         | -0.6                     | M S                      | MV UNIT CORRECTION + 22.4 | ΔV RANGE CORRECTION    |            | +13                    |          |         |
|                                                               |                            |                          |                          |                           |                        |            | TOTAL RANGE CORRECTION | -254     |         |
|                                                               |                            |                          |                          |                           |                        |            | -250                   |          |         |
| MET FUZE CORRECTION                                           |                            |                          |                          |                           |                        |            |                        |          |         |
|                                                               | VARIATION FROM STANDARD    | UNIT CORRECTION          | PLUS                     | MINUS                     | TOTAL FUZE CORRECTION  |            |                        |          |         |
| ΔV                                                            | 0.6                        | -0.040                   |                          | .024                      | MET FUZE CORRECTION    |            | +0.1                   |          |         |
| RANGE WIND                                                    | 14                         | +0.003                   | .042                     |                           | FUZE CORRECTION        |            | -0.2                   |          |         |
| AIR TEMP                                                      | 2.0                        | -0.006                   |                          | .012                      | TOTAL FUZE CORRECTION  |            | -0.1                   |          |         |
| AIR DENSITY                                                   | 1.9                        | +0.050                   | .095                     |                           |                        |            |                        |          |         |
| PROJ WEIGHT                                                   | 2                          | +0.019                   | .038                     |                           |                        |            |                        |          |         |
|                                                               |                            |                          |                          |                           |                        |            | .175                   |          |         |
|                                                               |                            |                          |                          |                           |                        |            | .036                   |          |         |
|                                                               |                            |                          |                          |                           |                        |            | .139                   |          |         |
| MIL FUZE CORR                                                 |                            |                          |                          |                           |                        |            |                        |          |         |
| OLD FZ CORR                                                   |                            |                          |                          |                           |                        |            |                        |          |         |
| NEW FZ CORR                                                   |                            |                          |                          |                           |                        |            |                        |          |         |
| DATE TIME                                                     |                            |                          |                          |                           |                        |            |                        |          |         |

DA FORM 7-4200 REPLACES DA FORM 515, 1 APR 67, WHICH IS OBSOLETE  
\* U.S. G.P.O. 1977-765037/45

Figure 13-18. Solution of met to the target.

## C1, FM 6-40

- ★ d. After the met is complete, the remainder of the computations can be determined rapidly using the right side of DA Form 4207. The total range correction from the met is applied to the chart range to determine a corrected range (fig 13-19).



|       |   |                               |       |
|-------|---|-------------------------------|-------|
| +146  | 1 | HOB Above Gun (from met form) | (1M)  |
| 10510 | 2 | Chart Rg to Tgt               | (10M) |
| -250  | 3 | Total Rg Corr (from met form) | (10M) |
| 10260 | 4 | Corrected Rg (2 plus 3)       | (10M) |

Figure 13-19. Determination of corrected range.

- e. The HES QE is determined by placing the MHL over the corrected range (block 4) to determine elevation. Site is then computed and added. Angle of site is also determined and entered at this time (fig 13-20).

|      |   |                                 |      |
|------|---|---------------------------------|------|
| 3/8  | 5 | El $\approx$ 4 (Use MHL)        | (1M) |
| +1.6 | 6 | Site (GST, VI 1 at Rg.2)        | (1M) |
| 334  | 7 | QE for Spotter (5 plus 6)       | (1M) |
| +14  | 8 | Angle of Site (GST, CdD Scales) | (1M) |

Figure 13-20. Determination of angle of site.

- f. Fuze setting for the HES round is determined by placing the MHL of the GFT over El + CAS to determine a fuze setting and adding the total fuze correction from the met data correction sheet to that fuze setting (fig 13-21).

|      |    |                               |       |
|------|----|-------------------------------|-------|
| 320  | 9  | El plus Comp Site (7 minus 8) | (1M)  |
| 29.2 | 10 | FS $\approx$ 9 (Use MHL)      | (0.1) |
| -0.1 | 11 | Total Fz Corr (from met form) | (0.1) |
| 29.1 | 12 | FS for Spotter (10 plus 11)   | (0.1) |

Figure 13-21. Ballistic corrections.

- g. Ballistic corrections from table M must be applied to the HES deflection, fuze setting, and QE to determine data to fire. Table M data is entered at items 13, 17, and 19.

|      |    |                             |       |
|------|----|-----------------------------|-------|
| +0.1 | 13 | Bal Fz Corr for NUC (Tbl M) | (0.1) |
| 29.2 | 14 | FS to Fire (12 plus 13)     | (0.1) |

- h. The fuze setting to fire is the fuze setting for the spotter plus the ballistic correction.

- i. The deflection to fire is determined by applying the total deflection correction from the met and the ballistic correction to the chart deflection.

- j. The quadrant to fire is the HES QE modified by the table M correction that was determined earlier. This completes the fire commands for this mission (fig 13-22).

|      |    |                                                   |        |
|------|----|---------------------------------------------------|--------|
| 2752 | 15 | Chf Df to Tgt                                     | (1M)   |
| L13  | 16 | Total DF Corr (from met form)                     | 0 (1M) |
| 0    | 17 | Bal Df Corr for NUC (Tbl M) $\approx$ 20.4 (0.1M) | (1M)   |
| 2765 | 18 | Df to Fire (15+16+17)                             | (1M)   |
| 334  | 19 | QE for Spotter 7                                  | (1M)   |
| +3   | 20 | Bal QE Corr for NUC (Tbl M)                       | (1M)   |
| 337  | 21 | QE to Fire (19+20)                                | (1M)   |

Figure 13-22. Completion of fire commands.

- k. There may be occasions when a position VE is not available and registration or observer adjustment is not possible. In these rare instances, a position VE may be extracted from the Approximate Loss in Muzzle Velocity table on page VIII of the tabular firing table (FT 8-R-1). This table may be entered with either a pullover gage reading

or equivalent full charge (EFC) erosion rounds as explained in the TFT. A loss in muzzle velocity is extracted. This extracted value may be used when no position VE exists, registration is impossible, and the observer adjustment technique is impossible.

### 13-5. Observer Adjustment Technique

a. If the information necessary for employing the met + VE technique or the K-transfer technique is not available and a nuclear round must be delivered, an adjustment may be made with shell HES followed by fire for effect with shell nuc (fig 13-23). This technique cannot be used if the availability of HES projectiles is critical. As with the previous techniques, a message from higher headquarters will contain target information. If the FDO decides to use the

observer adjustment technique, an observer who can be positioned to observe the target must be notified by secure message. The adjustment procedure will differ from that of a normal HE adjustment. The observer must adjust deviation, range, and height of burst (HOB is adjusted to 20 meters) simultaneously. The deflection, elevation, site, 100/R, and fuze setting are determined in the same manner as for shell HE. The fuze setting is not determined by the elevation plus comp site method during the adjustment phase because the vertical interval normally will be small and the observer will correct automatically for small errors during the adjustment.

b. For the initial data, 20/R based on the chart range is added to ground site. When a subsequent height-of-burst correction in meters is given by the observer, the computer uses the 100/R factor to determine the height-of-burst correction in mils. He then applies the height-of-burst correction to the previous site. For example, the observers height-of-burst correction is **DOWN 20** and 100/R is 29 mils. The computer determines the height-of-burst correction to be **-6**. With a previous site (including 20/R) of **+12**, the new site is **+6**.

c. The chart data in the fire for effect phase is determined in the same manner as in the adjustment phase. The observer's fire for effect request should place the burst over the target with a height of burst of 20 meters. The height above the target must be corrected by the differences between the height of the last round in the adjustment and the desired height above target for the nuclear round. This is illustrated in figure 13-24. To determine nuclear data to fire, the computer must make a site correction by using a height-of-burst correction and the initial chart range to compute site. This site correction is included as a height-of-burst correction to the last site fired. The new total site (**+20**) is added to the HES elevation corresponding to the chart range to determine an HES QE. El + CAS is determined in the same manner as the K-transfer and met + VE techniques (HES QE minus angle of site). Angle of site is computed using an HOB of **+198** (desired HOB **(+180)** + initial VI **(+18)**). Entry arguments into table

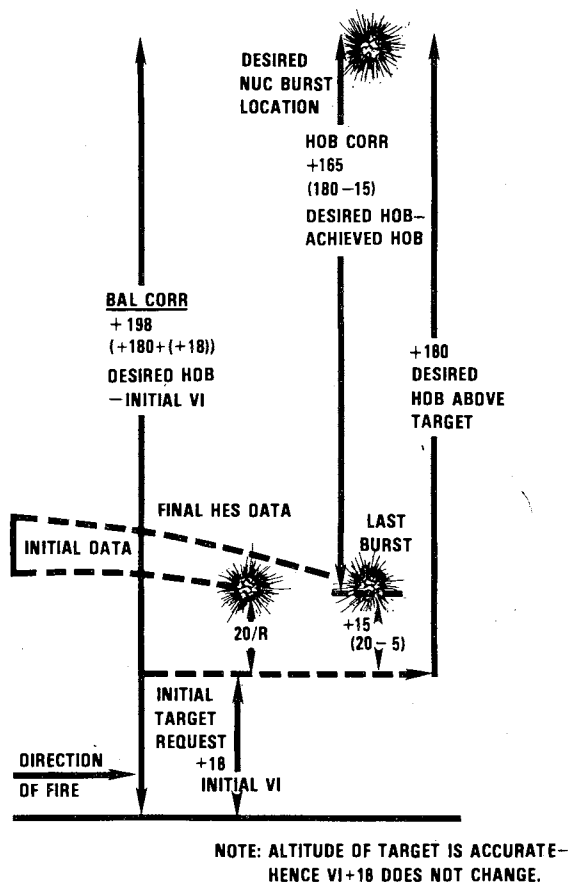


Figure 13-23. An adjustment may be made with shell HES followed by fire for effect with shell nuc.

## RECORD OF FIRE

|                                                                                    |  |  |  |  |  |  |  |  |  |                                                                                                                  |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
|------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--------------------------|--|--|--|--|--|--|--|--|--|-------------------------------|--|------------|--|--|--|--|--|--|--|------------|--|
| CALL FOR FIRE                                                                      |  |  |  |  |  |  |  |  |  | TGT ALT 383<br>BTRY ALT 365<br>VI + 18                                                                           |  |  |  |  |  |  |  |  |  | △ FS                     |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| Observer: 5886 3795 ALT 383                                                        |  |  |  |  |  |  |  |  |  | AF/FE/IS/S                                                                                                       |  |  |  |  |  |  |  |  |  | 100/R 9                  |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| Polar: Dir                                                                         |  |  |  |  |  |  |  |  |  | U/D                                                                                                              |  |  |  |  |  |  |  |  |  | /R                       |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| Shift: HOB 180                                                                     |  |  |  |  |  |  |  |  |  | L/R                                                                                                              |  |  |  |  |  |  |  |  |  | 20/R 2                   |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| FIRE ORDER #1 USE GFT, SHES, LOT RS, CHG 3, FZ TI, ① SHNUC, LOT PT, FZ TI, HOB 180 |  |  |  |  |  |  |  |  |  | Df Corr 0                                                                                                        |  |  |  |  |  |  |  |  |  | HOB Corr +2              |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| INITIAL FIRE COMMANDS                                                              |  |  |  |  |  |  |  |  |  | Rg 11450                                                                                                         |  |  |  |  |  |  |  |  |  | Cht Df 3289              |  |  |  |  |  |  |  |  |  | EI 387                        |  |            |  |  |  |  |  |  |  |            |  |
| Sp Instr RMC                                                                       |  |  |  |  |  |  |  |  |  | Sh HES Lot RS Chg 3 Fz TI Ti 342                                                                                 |  |  |  |  |  |  |  |  |  | Df 3289                  |  |  |  |  |  |  |  |  |  | QE 391                        |  |            |  |  |  |  |  |  |  |            |  |
| MTO ADJUST ON GRID 5886 3795, NUC 1/2 REPORT WHEN READY TO OBSERVE                 |  |  |  |  |  |  |  |  |  | PER                                                                                                              |  |  |  |  |  |  |  |  |  | TF                       |  |  |  |  |  |  |  |  |  | ① SHNUC, LOT PT, FZ TI in Eff |  | Ammo Exp ① |  |  |  |  |  |  |  |            |  |
| Tgt Location                                                                       |  |  |  |  |  |  |  |  |  | Priority Firing Unit                                                                                             |  |  |  |  |  |  |  |  |  | SUBSEQUENT FIRE COMMANDS |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| Dir MF Sh, Fz                                                                      |  |  |  |  |  |  |  |  |  | Dev Rg HOB Corr MF, Sh, Chg, Fz FS Corr Ti Chart Df Df Corr (O) Df Fired Chart Rg HOB Corr Si (H) EI QE Exp Type |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| 830 L30 +200 U20                                                                   |  |  |  |  |  |  |  |  |  | 351 3293 0 3293 11640 -2 +2 398 400 ②                                                                            |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| R20 -100 W10                                                                       |  |  |  |  |  |  |  |  |  | 347 3291 0 3291 11550 -1 +1 393 394 ③ HES                                                                        |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| -50 U5 FE SHNUC LOT PT                                                             |  |  |  |  |  |  |  |  |  | (342) 3290 0 (3290) 11510 +17 +18 389 (407)                                                                      |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| FZ TI                                                                              |  |  |  |  |  |  |  |  |  | 402 R 1 -16 +3                                                                                                   |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| HOB CORRECTION                                                                     |  |  |  |  |  |  |  |  |  | (342) 3289 114943 11490 (410) ① NUC                                                                              |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| DESIRED HOB +180                                                                   |  |  |  |  |  |  |  |  |  |                                                                                                                  |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| - ACHIEVED HOB -(+15)                                                              |  |  |  |  |  |  |  |  |  | RG CORR FOR WT                                                                                                   |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| HOB CORR +165                                                                      |  |  |  |  |  |  |  |  |  | INITIAL CHT Rg 11450                                                                                             |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| ST CORR (165 ÷ 1450) + 17                                                          |  |  |  |  |  |  |  |  |  | + COMP RG (TBLR) + 35                                                                                            |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| + LAST ST FIRED + 1                                                                |  |  |  |  |  |  |  |  |  | ENTRY RG 11485 ≈ 11500                                                                                           |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| TOT ST +18                                                                         |  |  |  |  |  |  |  |  |  | UNIT CORR 116 DECREASE WT (TBLR) -4                                                                              |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| - ST (198 ÷ 11450) + 20                                                            |  |  |  |  |  |  |  |  |  | X WT DIFF (SPOT → HOT) 416                                                                                       |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| CAS -2                                                                             |  |  |  |  |  |  |  |  |  | RG CORR FOR PROT DIFF -16M                                                                                       |  |  |  |  |  |  |  |  |  |                          |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| EL 389                                                                             |  |  |  |  |  |  |  |  |  |                                                                                                                  |  |  |  |  |  |  |  |  |  | HES WT 244               |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| EL + CAS 387                                                                       |  |  |  |  |  |  |  |  |  |                                                                                                                  |  |  |  |  |  |  |  |  |  | NUC WT 240               |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| FS ~ EL + CAS = 34.2                                                               |  |  |  |  |  |  |  |  |  |                                                                                                                  |  |  |  |  |  |  |  |  |  | - 416                    |  |  |  |  |  |  |  |  |  |                               |  |            |  |  |  |  |  |  |  |            |  |
| Btry                                                                               |  |  |  |  |  |  |  |  |  | DTG                                                                                                              |  |  |  |  |  |  |  |  |  | Tgt                      |  |  |  |  |  |  |  |  |  | Replot Grid                   |  |            |  |  |  |  |  |  |  | Replot Alt |  |

DA FORM 4504  
1 OCT 78

REPLACES DA FORM 4504, 1 MAY 76, WHICH IS OBSOLETE

FOR USE OF THIS FORM, SEE FM 6-40;  
THE PROponent AGENCY IS TRADOC

Figure 13-24. Adjustment of the height of burst.

M are VI + 198 and HES QE 411. The ballistic corrections are applied to the HES FS, df, and QE to determine data to fire.

*Note.* If there is a difference in projectile weight and/or propellant temperature, an entry range must be computed using VI (+198 ≈ +200) and chart range 11450 ≈ 11400. The final chart range must be modified by the range correction for projectile weight and propellant temperature before the elevation can be determined. This parallels the procedure used in the K-transfer technique. There is no difference in projectile weights and propellant temperatures in this mission.

## 13-6. FADAC Procedures

a. FADAC computation of firing data for the 8-inch M422A1 nuclear projectile can be

accomplished using the same delivery techniques discussed for manual procedures:

- (1) K-transfer.
- (2) Met + range K (same as manual met + VE).
- (3) Observer adjustment.

b. The preferred techniques are K-transfer and met + range K. The requirements and considerations for selection of a delivery technique are the same as discussed in paragraph 13-2.

c. FADAC delivery techniques are:

(1) *Registration.* A three-round high burst registration with one weapon using shell HES should be fired immediately after occupying position. High burst procedures for shell HES are the same as shell HE except

that FADAC does not automatically apply 20/R for fuze M543 when computing firing data; therefore, a target altitude change of 20 meters as in normal HE procedures is unnecessary. However, a nuc HOB must be entered before computing firing data. This entry will be zero if the HOB above grid is included in the target altitude or can be the HOB above the grid altitude.

(2) *Met + range K.* The residuals applied in this technique were determined with valid met and ammunition data and as a result reflect only position or constant errors. FADAC uses these residuals with current met and ammunition data. Range K and fuze corrections determined in this manner may be averaged and carried from position to position.

(3) *K-transfer.* This technique is used when current HES residuals from a registration are available, but current met data is not. The FDO may use standard met or the most current met available. Generally standard met is used because the residuals include corrections that account for unknown met conditions.

(4) *Observer adjustment.* When data for conducting other methods of nuclear delivery is not available, the observer adjustment

must be used. The procedure is different from normal HE adjustment in that the FO must simultaneously adjust deviation, range, and HOB (as required) after each round.

(5) *Ballistic corrections.* The FADAC program automatically compensates for the ballistic differences between the HES projectile and the nuc projectile and their respective fuzing systems for all techniques. However, a muzzle velocity entered for the HES projectile will not be automatically used for the nuc projectile.

(6) *Nuclear HOB.* The desired HOB is a required entry for both HES and nuc missions. This acts as a safeguard to insure an HOB has been entered before computation. FADAC will not yield a solution if no entry has been made.

d. A detailed discussion of FADAC procedures can be found in the FADAC User's Manual (TM 9-1220-221-10/CL).



*Note.* There may be occasions when a position VE is not available and registration or observer adjustment is not possible. In these rare instances, a position VE may be extracted from the approximate Loss in Muzzle Velocity table of the TFT. Information as to how to extract the data is listed in the TFT.

## Section II. 155-MM HOWITZER NUCLEAR DELIVERY

★ In addition to the 8-inch howitzer, the US nuclear inventory includes the 155-mm howitzer system, towed or self-propelled, which has the capability of nuclear delivery. The 155-mm nuclear round does not have a ballistically matched projectile that can be used for registration as the 8-inch nuclear projectile does; therefore, the procedure to solve the nuclear gunnery problem requires some modification. The 155-mm nuclear round consists of the atomic projectile M454; propellant charges M206, M207, or M197; sequential timer M32E1; and a fuze system which has mechanical time and VT options. The VT fuze is armed by the sequential timer

and has a high or low option that must be selected.

### 13-7. Delivery Techniques

Currently there are three delivery techniques available for the 155-mm nuclear projectile: met correction, K-transfer, and observer adjustment. The firing data for all techniques is determined to the same accuracy as are conventional gunnery procedures.

a. *Met Correction.* The met correction technique uses a position deflection

correction from an HE registration/concurrent met and a VE determined based on tube erosion to solve a met to the target.

(1) *Requirements.* The met correction technique requires an accurately located target and current met data. In addition, position deflection correction and a VE based on erosion are necessary. Because HE, M107 and the nuclear projectile are not ballistically matched, the HE position VE and M564 fuze correction are not used. The HE position deflection is not affected by projectile type; therefore, it is applied when the met correction technique is used to determine firing data. The position fuze correction is assumed to be 0.0. The VE, expressed as a loss in muzzle velocity due to tube erosion, is determined from a recent pullover gage reading or from EFC rounds for erosion as discussed in paragraph 13-9.

(2) *Accuracy.* The met correction technique is generally the most accurate. The accuracy depends upon the validity of the met message and the accuracy of the erosion data.

(3) *Speed.* The met correction technique is slower than the K-transfer technique because a met to the target must be solved.

*b. K-transfer.* With the K-transfer technique, HE GFT setting is used to determine HE data to the target, then this data is modified for the nuclear round.

(1) *Requirements.* To use the K-transfer technique, there must be a valid HE GFT setting and the target must be accurately located and within transfer limits. In applying HE corrections, the HE charge to nuclear charge correlation in table 13-1 is assumed.

(2) *Accuracy.* The accuracy of the K-transfer technique depends upon the validity of the GFT setting. Changes in weather will invalidate the GFT setting. A disadvantage of the K-transfer technique is the error induced by applying HE data in determining firing data for the nuclear round. Use of HE, charges 4 and 5 GB registration corrections is preferred to use of charges 4 and 5 WB because the differences between the standard muzzle velocities for M3A1 (GB) and M206 are less than the differences between M4A2 (WB) and M206.

(3) *Speed.* The K-transfer technique is the fastest method for determining data.

*c. Observer Adjustment.* In this technique, the observer adjusts HE onto the target, then nuclear data is determined.

(1) *Requirements.* The observer adjustment technique requires an observer to be in position to observe.

(2) *Accuracy.* The accuracy of the observer adjustment technique depends on the accuracy of the observer's adjustment.

Table 13-1. HE to Nuclear Charge Correlation

| M109A1, M109, M114A1     | M109, M114A1                            | M109A1                                  |
|--------------------------|-----------------------------------------|-----------------------------------------|
| HE, M107,<br>PROPELLANTS | NUCLEAR PROJECTILE,<br>M454 PROPELLANTS | NUCLEAR PROJECTILE,<br>M454 PROPELLANTS |
| <u>CHARGE</u>            | <u>CHARGE</u>                           | <u>CHARGE</u>                           |
| 4 (GB OR WB)             | 1 (M206)                                | 1 (M206)                                |
| 5 (GB OR WB)             | 2 (M206)                                | 2 (M206)                                |
| 7 (WB)                   | 3 (M207)                                | 3 (M197)                                |

(3) *Speed.* The observer adjustment technique is the slowest.

### 13-8. Use of the Firing Tables

a. The 155-mm howitzer model governs which firing tables will be used for computation of nuclear firing data. The tables to use are the FT 155-AJ-2 for the M109, M109A1, and M114A2, and the FT 155-AI-2 for the M114 and M114A1. The use of one of the tables to determine firing data is required because there is no 155-mm nuclear graphical equipment. All data in this chapter will be from FT 155-AJ-2.

★ *Note.* FT 155-AJ-2 will be used for the M109A1 howitzer.

b. When an HE GFT setting and GFT deflection correction are used in K-transfer or when shell HE, M107 is used in observer adjustment, the HE fire for effect data to the target (fuze setting, deflection, and quadrant elevation) are modified by ballistic corrections obtained from table O, FT 155-AJ-2.

#### BALLISTIC CORRECTIONS

OF CORRECTION L4 TIME SETTING CORRECTIONS +1.1 DE CORRECTION +20

(2) THESE BALLISTIC CORRECTIONS ARE APPLIED DIRECTLY TO THE FINAL HE DATA:

|                                   | DEFLECTION | FUZE SETTING | QUADRANT ELEVATION |
|-----------------------------------|------------|--------------|--------------------|
| FINAL HE DATA                     | 3310       | 19.2         | 365                |
| + CORRECTIONS                     | <u>L4</u>  | <u>+1.1</u>  | <u>+20</u>         |
| = M454 DATA FOR                   |            |              |                    |
| DF & DE AND                       | 3314       |              | 385                |
| INTERMEDIATE TIMER SETTING, M32E1 |            | 20.3         |                    |

c. Regardless of the delivery technique used, corrections for temperature are included in the determination of the timer setting for the sequential timer. This is required because the functioning of the timer is sensitive to temperature. There are no means readily available to directly measure the temperature of the sequential timer. However, a reliable correction can be obtained by using the nuclear propellant temperature. Table K lists the values to be applied to the intermediate timer setting. Table K requires two entry arguments:

- (1) nuclear propellant temperature
- (2) intermediate timer setting

CHANGE  
1

TABLE K  
TIMER TEMPERATURE

FT 155-AJ-2  
PROJ. ATOMIC, XP454  
ST. M32E1

CORRECTIONS TO TIMER SETTING FOR TIMER TEMPERATURE

| TEMPERATURE<br>OF<br>TIMER<br>DEGREES F | INTERMEDIATE TIMER SETTING |      |      |      |      |      |      |
|-----------------------------------------|----------------------------|------|------|------|------|------|------|
|                                         | 0                          | 10   | 20   | 30   | 40   | 50   | 60   |
| -40                                     | 0.0                        | -0.3 | -0.6 | -0.9 | -1.2 | -1.5 | -1.8 |
| -35                                     | 0.0                        | -0.2 | -0.4 | -0.6 | -0.8 | -1.0 | -1.2 |
| -30                                     | 0.0                        | -0.2 | -0.3 | -0.5 | -0.6 | -0.8 | -0.9 |
| -25                                     | 0.0                        | -0.1 | -0.2 | -0.4 | -0.5 | -0.6 | -0.7 |
| -20                                     | 0.0                        | -0.1 | -0.2 | -0.3 | -0.4 | -0.5 | -0.6 |
| -15                                     | 0.0                        | -0.1 | -0.2 | -0.2 | -0.3 | -0.4 | -0.5 |
| -10                                     | 0.0                        | -0.1 | -0.1 | -0.2 | -0.2 | -0.3 | -0.4 |
| -5                                      | 0.0                        | -0.1 | -0.1 | -0.1 | -0.2 | -0.3 | -0.3 |
| 0                                       | 0.0                        | 0.0  | -0.1 | -0.1 | -0.2 | -0.2 | -0.3 |
| 5                                       | 0.0                        | 0.0  | -0.1 | -0.1 | -0.2 | -0.2 | -0.2 |
| 10                                      | 0.0                        | 0.0  | -0.1 | -0.1 | -0.1 | -0.2 | -0.2 |
| 15                                      | 0.0                        | 0.0  | -0.1 | -0.1 | -0.1 | -0.1 | -0.2 |
| 20                                      | 0.0                        | 0.0  | 0.0  | -0.1 | -0.1 | -0.1 | -0.1 |
| 25                                      | 0.0                        | 0.0  | 0.0  | -0.1 | -0.1 | -0.1 | -0.1 |
| 30                                      | 0.0                        | 0.0  | 0.0  | 0.0  | -0.1 | -0.1 | -0.1 |
| 35                                      | 0.0                        | 0.0  | 0.0  | 0.0  | -0.1 | -0.1 | -0.1 |
| 40                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | -0.1 | -0.1 |
| 45                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | -0.1 |
| 50                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 55                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 60                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 65                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 70                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 75                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 80                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 85                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 90                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 95                                      | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 100                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 105                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| 110                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  |
| 115                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  |
| 120                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  |
| 125                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  | 0.1  |
| 130                                     | 0.0                        | 0.0  | 0.0  | 0.0  | 0.0  | 0.1  | 0.1  |

Nuclear propellant temperature +12°F, (enter left-hand column at the nearest listed value, +10).

Intermediate timer setting M32E1, 20.3 (enter vertical column at nearest listed value, 20).

At the intersection of the entry arguments, extract the correction for timer temperature as listed, -0.1.

The corrected timer setting for the sequential timer would be 20.2.

|                                |         |
|--------------------------------|---------|
| Intermediate timer setting     | 20.3    |
| + Temperature correction       | +(-0.1) |
| Corrected timer setting, M32E1 | 20.2    |

d. When the VT option is used, the T361E2 fuze is armed by the M32E1 sequential timer. For the VT option to function properly, a back-off correction must be obtained from table L and applied to the corrected M32E1 timer setting. Table L requires two entry arguments:

- (1) nuclear propellant temperature
- (2) corrected M32E1 timer setting

b. TM 38-750, paragraph 4-6, dictates that a DA Form 2408-4 will be maintained in order to "provide a continuous record of firings and other information related to the service life of weapons with cannon or mortar tubes." These EFC rounds are recorded to keep track of tube fatigue. It is these rounds that will condemn a cannon tube; they are also used to determine the equipment serviceability criteria (ESC) rating for the cannon tube.

Timer setting M32E1, 20.2 (enter left-hand column at nearest listed value, 20).

Timer temperature (propellant temperature) is +12°F. (enter vertical column at nearest listed value, -15°F. to 125°F.).

At the intersection of the entry arguments, extract the back-off correction of -1.5.

*Note.* All corrections in table L are negative values.

The VT fuze setting will be 18.7.

|                                  |         |
|----------------------------------|---------|
| Corrected timer setting          | 20.2    |
| + Back-off correction, table L   | +(-1.5) |
| M32E1 fuze setting for VT option | 18.7    |

*Note.* The accuracy for VT fuze settings for the nuclear round is to the nearest 0.1 increment.

FT 155-AJ-2

PROJ, ATOMIC, XM454  
FUZE, PROXIMITY, T361E2

TABLE L

BACK-OFF TIME

CHANGE  
1

CORRECTION TO TIMER SETTING FOR FUZE, T361E2

| CORRECTED<br>TIMER<br>SETTING | TEMPERATURE OF TIMER<br>DEGREES F |     |     |     |     |                  |
|-------------------------------|-----------------------------------|-----|-----|-----|-----|------------------|
|                               | -40                               | -35 | -30 | -25 | -20 | -15<br>TO<br>125 |
| 0                             | 1.2                               | 1.2 | 1.2 | 1.2 | 1.2 | 1.2              |
| 5                             | 1.2                               | 1.2 | 1.2 | 1.2 | 1.2 | 1.2              |
| 10                            | 1.4                               | 1.3 | 1.3 | 1.3 | 1.3 | 1.3              |
| 15                            | 1.6                               | 1.5 | 1.4 | 1.4 | 1.4 | 1.4              |
| 20                            | 1.8                               | 1.6 | 1.6 | 1.5 | 1.5 | 1.5              |
| 25                            | 2.0                               | 1.8 | 1.7 | 1.7 | 1.7 | 1.7              |
| 30                            | 2.2                               | 2.0 | 1.9 | 1.8 | 1.8 | 1.8              |
| 35                            | 2.4                               | 2.2 | 2.0 | 2.0 | 2.0 | 1.9              |
| 40                            | 2.7                               | 2.3 | 2.2 | 2.2 | 2.1 | 2.1              |
| 45                            | 2.9                               | 2.5 | 2.4 | 2.3 | 2.3 | 2.2              |
| 50                            | 3.1                               | 2.7 | 2.6 | 2.5 | 2.4 | 2.4              |
| 55                            | 3.3                               | 2.9 | 2.7 | 2.6 | 2.6 | 2.6              |
| 60                            | 3.6                               | 3.1 | 2.9 | 2.8 | 2.8 | 2.7              |

c. EFC rounds for erosion are recorded for the purpose of a continuous update of muzzle velocity loss. The two tables used for the determination of velocity error correction for erosion are:

- (1) Charge erosion life factor, table 13-2.
- (2) Loss in muzzle velocity, table 13-3.

These tables are included in change 5 to FT 155-AJ-2. Table 13-2 contains the erosion factors by charge and propellant type used to compute the number of EFC service rounds for erosion. Note the difference between the erosion life equivalent factors for the white bag and green bag propellants. Data

### 13-9. MV Loss Due to Erosion

a. A velocity error correction is required when computing nuclear firing data using the met correction technique for the M109A1 weapon system. To determine this velocity error for erosion, two tables are used. Before discussing the tables, the difference between EFC rounds for erosion and the EFC rounds as recorded on the DA Form 2408-4 must be understood.



Table 13-2. Charge Erosion Life Factor

| Zone | Erosion Life |
|------|--------------|
| 8    | 1.00         |
| 7W   | .30          |
| 6W   | .12          |
| 5W   | .042         |
| 4W   | .018         |
| 3W   | .0088        |
| 5G   | .029         |
| 4G   | .010         |
| 3G   | .0051        |
| 2G   | .0026        |
| 1G   | .0013        |

*Note.* This table makes use of the term "zone." The terms "zone" and "charge" are interchangeable.

computed using table 13-2 can be used as an entry into table 13-3. The use of table 13-2 is illustrated below:

**Example:**

An M109A1 howitzer has fired the following:

400 rounds charge 4GB

400 rounds charge 6WB

50 rounds charge 8

$$400 \times .010 = 4$$

$$400 \times .12 = 48$$

$$50 \times 1.00 = 50$$

$$\text{Erosion EFC} = 102$$

Table 13-3 may also be entered using a current pullover gage reading.

d. The methods of determining loss in MV due to erosion are:

(1) Use the current wear measurement from a pullover gage test.

(2) If the pullover gage data is not current, EFC service rounds for erosion must

be used. FDC personnel must keep a record of the number of rounds and charge fired by each weapon in order to keep this data current. The number of rounds of each charge is multiplied by the charge erosion life factor listed in the TFT as shown above. A point to remember is that whenever a pullover gage test is taken, the results take precedence over the round-by-round computations.

**Example:**

A 155-mm nuclear fire mission has been received and will be fired with zone 3 by section 2. The pullover gage reading is 6.116 inches. The wear measurement column is entered to the nearest listed value (6.116-6.118). The value from zone 3 (corresponding to 6.118) is then extracted. The value of -3.1 becomes the position VE in the met correction technique.

e. The values extracted from table 13-3 can be used for zones 2 and 3 without modification. Zone 1 computations require a slight modification. TFT 155-AJ-2 contains data for the M109. Charges 2 and 3 data in this TFT for the M109 is close enough to use for the M109A1, but charge 1 data is not. Therefore, a corrected VE is necessary when using charge 1 with the met correction technique. Charge 1 data is modified by applying a +2.4 m/s to the value extracted from table 13-3.

★ **Example:**

(1) A nuclear fire mission, charge 1, has been received at the FDC. Section 2 will fire the mission. Section 2 has an erosion EFC value of 562 rounds. No current pullover gage reading is available.

(2) The FDC enters table 13-3 at 600 (closest listed value) and extracts a corrected VE of +1.6.

Table 13-3. Approximate Losses in Muzzle Velocity

| ★<br>NUMBER OF EQUIVALENT<br>(EROSION) FULL CHARGE<br>SERVICE ROUNDS FOR<br>PROJECTILE, HE, M107 | WEAR MEASUREMENT<br>(INCHES)** | CHANGE IN MUZZLE VELOCITY<br>FOR PROJECTILE,<br>ATOMIC, M454<br>(METERS PER SECOND) |        |                |
|--------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------|--------|----------------|
|                                                                                                  |                                | ***<br>ZONE 1                                                                       | ZONE 2 | ****<br>ZONE 3 |
| 0                                                                                                | 6.100                          | 2.4                                                                                 | 0.0    | 0.0            |
| 200                                                                                              | 6.109                          | 2.1                                                                                 | -0.3   | -1.7           |
| 400                                                                                              | 6.118                          | 1.7                                                                                 | -0.7   | -3.1           |
| 600                                                                                              | 6.122                          | 1.6                                                                                 | -0.8   | -4.0           |
| 800                                                                                              | 6.128                          | 1.4                                                                                 | -1.0   | -5.1           |
| 1000                                                                                             | 6.134                          | 1.2                                                                                 | -1.2   | -6.2           |
| 1200                                                                                             | 6.140                          | 0.8                                                                                 | -1.6   | -7.5           |
| 1400                                                                                             | 6.146                          | 0.4                                                                                 | -2.0   | -8.3           |
| 1600                                                                                             | 6.152                          | 0.2                                                                                 | -2.2   | -9.5           |
| 1800                                                                                             | 6.157                          | -0.5                                                                                | -2.9   | -10.5          |
| 2000                                                                                             | 6.163                          | -0.8                                                                                | -3.2   | -11.5          |
| 2200                                                                                             | 6.168                          | -1.5                                                                                | -3.9   | -12.5          |
| 2400                                                                                             | 6.172                          | -2.1                                                                                | -4.5   | -13.2          |
| 2600                                                                                             | 6.177                          | -2.5                                                                                | -4.9   | -14.2          |
| 2800                                                                                             | 6.181                          | -2.9                                                                                | -5.3   | -14.9          |
| 3000                                                                                             | 6.186                          | -3.6                                                                                | -6.0   | -15.6          |
| 3200                                                                                             | 6.190                          | -4.5                                                                                | -6.9   | -16.3          |
| 3400                                                                                             | 6.193                          | -4.9                                                                                | -7.3   | -16.9          |
| 3600                                                                                             | 6.196                          | -5.4                                                                                | -7.8   | -17.4          |
| 3800                                                                                             | 6.200                          | -6.0                                                                                | -8.4   | -18.3          |
| 4000                                                                                             | 6.203                          | -6.6                                                                                | -9.0   | -18.8          |
| 4200                                                                                             | 6.206                          | -7.3                                                                                | -9.7   | -19.3          |
| 4400                                                                                             | 6.208                          | -7.6                                                                                | -10.0  | -19.7          |
| 4600                                                                                             | 6.210                          | -7.9                                                                                | -10.3  | -20.0          |
| 4800                                                                                             | 6.212                          | -8.4                                                                                | -10.8  | -20.3          |
| 5000                                                                                             | 6.214                          | -8.8                                                                                | -11.2  | -20.9          |

\*\* THE WEAR MEASUREMENT IS TAKEN 39.6 INCHES FORWARD OF THE REAR FACE OF THE TUBE FOR CANNON, M185 AND 41.75 INCHES FORWARD OF THE REAR FACE OF THE TUBE FOR CANNON, M199.

\*\*\* THE MUZZLE VELOCITY FOR ZONE 1 WHEN FIRED FROM HOWITZERS, M109A1 AND M198 IS 313.3 M/S. THIS TABLE INCLUDES A +2.4 M/S CORRECTION TO COMPENSATE FOR THIS INCREASE.

\*\*\*\* ZONE 3 IS NOT AUTHORIZED FOR USE WITH CANNON, M199.

VI (E)

(3) The corrected VE, charge 1, M109A1 for this example would be +1.6 m/s.

### 13-10. Met Correction Technique

The following is an example of the met correction technique for delivery of the M454 nuclear projectile armed by the sequential timer M32E1.

a. Normally, calls for nuclear fire will be received as classified messages. In the following samples, only those portions of the calls for fire that are needed to determine firing data are shown. The FDO issued the following fire orders:

NUMBER 1, USE TFT, SHELL NUC,  
LOT QUEBEC ZULU, CHARGE 2,  
FUZE TIME, HEIGHT OF BURST 40  
METERS, AT MY COMMAND.

b. Additional information to solve the met correction technique:

(1) Determination of azimuth to target:

|                      |           |
|----------------------|-----------|
| Chart deflection     | 3352 mils |
| Common deflection    | 3200 mils |
| Change in deflection | L152 mils |
| Azimuth of lay       | 6350 mils |
| Change in azimuth    | L152 mils |
| Azimuth to target    | 6198 mils |

(2) Current met data is shown in figure 13-25.

(3) Current weapon information to determine loss in muzzle velocity:

|                                         |       |
|-----------------------------------------|-------|
| ★ Pullover gage reading                 | 6.145 |
| Loss in muzzle velocity<br>(table 13-3) | -2.0  |

| BALLISTIC MET MESSAGE                                                                             |                |                              |                                                                                                                        |                               |                           |                                                            |                       |                                |                              |
|---------------------------------------------------------------------------------------------------|----------------|------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------------|------------------------------------------------------------|-----------------------|--------------------------------|------------------------------|
| For use of this form, see FM 6-15; the proponent agency is United States Continental Army Command |                |                              |                                                                                                                        |                               |                           |                                                            |                       |                                |                              |
| IDENTIFICATION                                                                                    | TYPE MSG       | OCTANT                       | LOCATION<br>L <sub>a</sub> L <sub>a</sub> L <sub>a</sub> L <sub>o</sub> L <sub>o</sub> L <sub>o</sub><br>or<br>xxx xxx |                               | DATE<br>YY                | TIME (GMT)<br>G <sub>o</sub> G <sub>o</sub> G <sub>o</sub> | DURATION (HOURS)<br>G | STATION HEIGHT (10's M)<br>hhh | MDP PRESSURE % OF STD<br>PPP |
| METB                                                                                              | K              | Q                            |                                                                                                                        |                               |                           |                                                            |                       |                                |                              |
| METB                                                                                              | 3              | 1                            | 345                                                                                                                    | 982                           | 26                        | 165                                                        | 0                     | 036                            | 974                          |
|                                                                                                   |                | BALLISTIC WINDS              |                                                                                                                        |                               | BALLISTIC AIR             |                                                            |                       |                                |                              |
| ZONE HEIGHT (METERS)                                                                              | LINE NUMBER ZZ | DIRECTION (100's MILS)<br>dd | SPEED (KNOTS)<br>FF                                                                                                    | TEMPERATURE (% OF STD)<br>TTT | DENSITY (% OF STD)<br>ΔΔΔ |                                                            |                       |                                |                              |
| SURFACE                                                                                           | 00             | 01                           | 11                                                                                                                     | 938                           | 043                       |                                                            |                       |                                |                              |
| 200                                                                                               | 01             | 05                           | 13                                                                                                                     | 936                           | 044                       |                                                            |                       |                                |                              |
| 500                                                                                               | 02             | 04                           | 15                                                                                                                     | 934                           | 047                       |                                                            |                       |                                |                              |
| 1000                                                                                              | 03             | 05                           | 21                                                                                                                     | 927                           | 049                       |                                                            |                       |                                |                              |
| 1500                                                                                              | 04             | 03                           | 21                                                                                                                     | 922                           | 053                       |                                                            |                       |                                |                              |
| 2000                                                                                              | 05             | 06                           | 18                                                                                                                     | 914                           | 055                       |                                                            |                       |                                |                              |
| 3000                                                                                              | 06             |                              |                                                                                                                        |                               |                           |                                                            |                       |                                |                              |
| 4000                                                                                              | 07             |                              |                                                                                                                        |                               |                           |                                                            |                       |                                |                              |
| 5000                                                                                              | 08             |                              |                                                                                                                        |                               |                           |                                                            |                       |                                |                              |

Figure 13-25. Current met data.

# C1, FM 6-40

(4) Accurate ammunition information:  
M454 projectile weight 118.5 pounds  
Propellant temperature +15° F.

(5) Current HE position deflection correction: L2

c. Using the data given above, met + VE data, and subsequent met procedures, the problem is solved as illustrated in figure 13-26.

★ (1) Since no graphical equipment for the 155-mm nuclear projectile is available, firing data for quadrant elevation and fuze setting is determined manually using the FT 155-AJ-2 and the C and D scales of the GST. This is accomplished as shown with the additional use of the DA Form 4505, used to help the computer organize his computations.

(2) The TFT must be used to extract both the elevation and the corresponding fuze

| MET DATA CORRECTION SHEET                                     |              |                            |                          |                  |                         |                        |               |              |            |                 |          |           |             |       |
|---------------------------------------------------------------|--------------|----------------------------|--------------------------|------------------|-------------------------|------------------------|---------------|--------------|------------|-----------------|----------|-----------|-------------|-------|
| For use of this form, see FM 6-40; proponent agency is TRADOC |              |                            |                          |                  |                         |                        |               |              |            |                 |          |           |             |       |
| BATTERY DATA                                                  |              |                            |                          |                  | MET MESSAGE             |                        |               |              |            |                 |          |           |             |       |
| CHARGE                                                        | 2            | ADJ QE                     |                          | CHART RG         | 5830                    | LATITUDE               | 30°N          | TYPE MESSAGE | MET R3     | OCTANT          | 1        | AREA/UNIT | 345 982     |       |
| ALT OF BTRY (10m)                                             |              |                            | 360                      |                  | DATE                    | 26                     | TIME          | 1630         | ALT MDP    | 360             | PRESSURE | 97.4      |             |       |
| ALT OF MDP                                                    |              |                            | 360                      |                  | LINE NO                 | 02                     | WIND DIR      | 400          | WIND SPEED | 15              | AIR TEMP | 93.4      | AIR DENSITY | 104.7 |
| BTRY ABOVE MDP (Ah)                                           |              |                            | —                        |                  | Ah CORRECTION           |                        |               | ±            | 0          | ±               | 0        |           |             |       |
| ALT OF TARGET (nearest meter)                                 |              |                            | 372                      |                  | CORRECTED VALUES        |                        |               |              | 93.4       |                 | 104.7    |           |             |       |
| HEIGHT OF BURST ABOVE TARGET                                  |              |                            | 40                       |                  |                         |                        |               |              |            |                 |          |           |             |       |
| ALT OF BURST                                                  |              |                            | 412                      |                  |                         |                        |               |              |            |                 |          |           |             |       |
| ALT OF BTRY (nearest meter)                                   |              |                            | 355                      |                  |                         |                        |               |              |            |                 |          |           |             |       |
| HEIGHT OF TARGET (burst) ABOVE GUN (M)                        |              |                            | +57 ≈ 100                |                  | COMP RG                 | +21                    | CHART RG      | 5830         | ENTRY RG   | 5851            | 5900     |           |             |       |
| WIND COMPONENTS AND DEFLECTION                                |              |                            |                          |                  |                         |                        |               |              |            |                 |          |           |             |       |
| WHEN DIRECTION OF WIND IS LESS THAN DIR FIRE ADD              |              |                            | 6400                     |                  | HE POS DF CORR L2       |                        |               |              |            |                 |          |           |             |       |
| DIRECTION OF WIND                                             |              |                            | 400                      |                  | MET DF CORR L7          |                        |               |              |            |                 |          |           |             |       |
|                                                               |              |                            | 6198                     |                  | TOTAL DF CORR L9        |                        |               |              |            |                 |          |           |             |       |
| DIRECTION OF FIRE                                             |              |                            | 6200                     |                  |                         |                        |               |              |            |                 |          |           |             |       |
| CHART DIRECTION OF WIND                                       |              |                            | 600                      |                  |                         |                        |               |              |            |                 |          |           |             |       |
| CROSS WIND                                                    | WIND SPEED   | 15                         | x COMP                   | 0.56             | 8                       | KNOTS                  | 0.30          | UNIT CORR    |            | CROSS WIND CORR | 2.4      |           |             |       |
| RANGE WIND                                                    | WIND SPEED   | 15                         | x COMP                   | 0.83             | 12                      | KNOTS                  | 12            | UNIT CORR    |            | MET DEFL CORR   | 6.8      | L7        |             |       |
| MET RANGE CORRECTION                                          |              |                            |                          |                  |                         |                        |               |              |            |                 |          |           |             |       |
|                                                               | KNOWN VALUES | STANDARD VALUES            | VARIATIONS FROM STANDARD | UNIT CORRECTIONS | PLUS                    | MINUS                  |               |              |            |                 |          |           |             |       |
| RANGE WIND                                                    | 12           | 0                          | 12                       | +7.9             | 94.8                    |                        |               |              |            |                 |          |           |             |       |
| AIR TEMP                                                      | 93.4         | 100%                       | 6.6                      | +16.1            | 106.3                   |                        |               |              |            |                 |          |           |             |       |
| AIR DENSITY                                                   | 104.7        | 100%                       | 4.7                      | +11.2            | 52.6                    |                        |               |              |            |                 |          |           |             |       |
| PROJ WEIGHT                                                   | 118.5        | 120.4                      | 1.9                      | -19.0            | 36.1                    |                        |               |              |            |                 |          |           |             |       |
| ROTATION                                                      |              |                            | +4X.87                   | 3.5              |                         |                        |               |              |            |                 |          |           |             |       |
| STD. WT. 120.45 ≈ 120.4                                       |              |                            |                          |                  | 257.2                   | 36.1                   |               |              |            |                 |          |           |             |       |
|                                                               |              |                            |                          |                  | -36.1                   |                        |               |              |            |                 |          |           |             |       |
|                                                               |              |                            |                          |                  | MET RANGE CORR          | 221.1                  | +221          |              |            |                 |          |           |             |       |
| COMPUTATION OF VE                                             |              |                            |                          |                  |                         |                        |               |              |            |                 |          |           |             |       |
| PROP TEMP                                                     | +15          | VE                         | -2.0                     | M.S.             | D+19.7                  | TOTAL RANGE CORRECTION |               |              |            |                 |          |           |             |       |
|                                                               |              | CHANGE TO MV FOR PROP TEMP | -2.6                     | M.S.             | I-16.9                  | MET RANGE CORRECTION   | +221          |              |            |                 |          |           |             |       |
|                                                               |              | ΔV                         | -4.6                     | M.S.             | MV UNIT CORRECTION 19.7 | ΔV RANGE CORRECTION    | +91           |              |            |                 |          |           |             |       |
|                                                               |              |                            |                          |                  | TOTAL RANGE CORRECTION  | +312                   | NOT EXPRESSED |              |            |                 |          |           |             |       |

Figure 13-26. Solution to met problem.

setting because there is no GFT for the 155-mm nuclear projectile. Table F of the TFT lists both the elevation and fuze setting necessary to continue the computations for firing data. The data can be extracted readily if the corrected range is an even hundred. In this example, as often is the case, the computer must interpolate to extract both the elevation and the fuze setting. The bottom of the record of fire may be used for these computations. The range recorded in block 3 includes complementary range (fig 13-27).

| 155mm NUCLEAR COMPUTATION-MET CORRECTION TECHNIQUE |                                     |              |         |                |
|----------------------------------------------------|-------------------------------------|--------------|---------|----------------|
| Entry A                                            | Piece Number 1                      | DTG 26 1645  | Tgt 853 |                |
| 1                                                  | Entry Rg (from met form)            | 5851 (1M)    |         | FIRING<br>DATA |
| 2                                                  | Total Rg Corr (from met form)       | +312 (1M)    |         |                |
| 3                                                  | Corrected Rg (1 plus 2) [6163 (1M)] | ≈ 6160 (10M) |         |                |
| 4                                                  | TS ~3 (TFT, Tbl F)                  | (0.1)        |         |                |

Figure 13-27. Determination of corrected range.

The elevation extracted based on this range, therefore, is elevation plus complementary angle of site. The computer now has an elevation + CAS of 302, and a fuze setting of 20.8. The elevation + CAS can be entered in block 17 (because the entry range has been modified by a range correction and is now a corrected entry range, all elevation values become elevation + CAS). The fuze setting is entered in block 4 (fig 13-28).

|   |                                      |            |      |
|---|--------------------------------------|------------|------|
| 3 | Corrected Rg (1 plus 2) [ (1M)]      | ≈ (10M)    | DATA |
| 4 | TS ~3 (TFT, Tbl F, Col 4)            | 20.8 (0.1) |      |
| 5 | Total Fz Corr to Tgt (from met form) | (0.1)      |      |
| 6 | Intermediate TS                      |            |      |

Figure 13-28. Entry of fuze setting.

(3) Before a fuze setting can be computed for the M32E1 fuze, the computer returns to the met data correction sheet to obtain a total fuze correction. The unit corrections are obtained from table J, and the entry used is 21.0 (20.8 ≈ 21.0) (fig 13-29).

| TS ~CORR'D Rg = 20.8 ± 21.0 MET FUZE CORRECTION |                         |                 |        |        |                            |
|-------------------------------------------------|-------------------------|-----------------|--------|--------|----------------------------|
| AV                                              | VARIATION FROM STANDARD | UNIT CORRECTION | PLUS   | MINUS  |                            |
| 4.6                                             |                         | -0.038          |        | -0.175 |                            |
| 18                                              |                         | -0.008          |        | -0.096 |                            |
| 6.6                                             |                         | -0.026          |        | -0.172 |                            |
| 4.7                                             |                         | -0.013          |        | -0.061 |                            |
| 1.9                                             |                         | +0.047          | +0.089 |        |                            |
|                                                 |                         |                 | +0.089 | -0.504 | TOTAL FUZE CORRECTION -0.4 |
|                                                 |                         |                 |        | +0.089 | MET FUZE CORRECTION 0.0    |
|                                                 |                         |                 |        | -0.415 | TOTAL FUZE CORRECTION -0.4 |
| MET FUZE CORR                                   |                         |                 |        |        |                            |
| OLD FZ CORR NEW FZ CORR                         |                         |                 |        |        |                            |
| TARGET NO. BATTERY DATE-TIME                    |                         |                 |        |        |                            |

Figure 13-29. Unit corrections from table J.

(4) After obtaining the total fuze correction, and applying it to the FS~corrected range, the computer has an intermediate timer setting, 20.4, which only needs to be adjusted for temperature correction (table K). These procedures were explained in paragraph 13-8c. The computer determines the time to fire to be 20.3 seconds (fig 13-30).

|    |                                      |            |            |
|----|--------------------------------------|------------|------------|
| 5  | Total Fz Corr to Tgt (from met form) | -0.4 (0.1) |            |
| 6  | Intermediate TS (4 plus 5)           | 20.4 (0.1) |            |
| 7  | Temp Corr (TFT, Tbl K)               | -0.1 (0.1) |            |
| 8  | Corrected TS (6 plus 7)              | 20.3 (0.1) |            |
| 9  | Back Off Time (VT ONLY) (TFT, Tbl L) | (0.1)      |            |
| 10 | TS to Fire (8 minus 9)               |            | 20.3 (0.1) |
| 11 | Chart Df                             | (1M)       |            |

Figure 13-30. Determination of time to fire.

(5) Deflection is computed by applying the total deflection correction to the chart deflection to the target. The result is 3361 (remember, the HE position deflection correction is part of the total deflection correction) (fig 13-31).

|    |                               |           |           |
|----|-------------------------------|-----------|-----------|
| 11 | Chart Df                      | 3352 (1M) |           |
| 12 | Total Df Corr (from met form) | 19 (1M)   |           |
| 13 | Df to Fire (11 plus 12)       |           | 3361 (1M) |
| 14 | HOB Above Gun (from met form) | (1M)      |           |
| 15 | Chart Rg                      | (1M)      |           |

Figure 13-31. Determination of deflection to fire.

(6) Finally, the QE has to be determined for the nuclear firing data to be complete. To determine the M454 QE, the angle of site is added to the elevation + CAS (already computed and entered in block 17). The angle of site is determined to be +10 (using C and D scales of any GST). The resulting quadrant elevation is 312 (fig 13-32).

|    |                                            |            |          |
|----|--------------------------------------------|------------|----------|
| 14 | HOB Above Gun (from met form)              | +57 (1M)   |          |
| 15 | Chart Rg                                   | 5830 (10M) |          |
| 16 | Angle of Site (14 plus 15 C&D Scales, GST) | +10 (1M)   |          |
| 17 | El ~3 (TFT, Tbl F, Col 2)                  | 302 (1M)   |          |
| 18 | QE to Fire (16 plus 17)                    |            | 312 (1M) |

DA FORM 1 MAY 14 4505

Figure 13-32. Determination of QE to fire.

## 13-11. K-Transfer Technique

The following is an example of the K-transfer technique for delivery of the M454 nuclear projectile with the VT fuze option on a target located at grid 61375 38315, altitude 390.

a. The fire direction officer issues his fire order.

NUMBER 6, USE GFT, SHELL NUC,  
LOT QUEBEC ZULU, CHARGE 1  
FUZE VT HIGH, ONE ROUND,  
HEIGHT OF BURST 60 METERS, AT  
MY COMMAND.

b. Required information to solve K-transfer firing data is:

(1) Valid HE, M107 corrections for nonstandard conditions obtained by a prior HE registration, chg 4 GB, at registration point 1.

GFT B: Chg 4, Lot XY, Rg 4850, El 302, Ti 17.9.

GFT Df Corr: L6.

Note. Charge 4 for shell M107 equates to charge 1 for shell M454.

(2) The nuclear propellant temperature reported by number 6 is +56° F.

c. The computer starts his computations by determining HE data (with the current GFT setting) to the nuclear target. This data is recorded on the record of fire and placed in parentheses (fig 13-33).

| RD OF FIRE                    |         |                      |          |
|-------------------------------|---------|----------------------|----------|
| TGT ALT 360<br>HOB + 60       |         | GFT L6<br>+ DRIFT L8 | △ F5     |
| BURST ALT 420<br>STRY ALT 352 |         |                      | 100/R    |
| VI + 68                       |         |                      | /R       |
| SI ÷ 10                       |         | 10m SI               | 20/R     |
| HIGH @ HOB 60, AMC            |         | Df Corr L14          | HOB Corr |
| Rg 5710                       |         | Chf Df 3056          | SI + 14  |
| Chg 1                         | Fz HIGH | Ti (220)             | El 376   |
| PER                           | TF      |                      | QE (390) |
|                               |         | in Eff               | Ammo Exp |

Figure 13-33. HE data to the nuclear target.

d. Ballistic corrections for deflection, fuze setting, and quadrant can be determined from table O by entering with HE QE 390. For convenience, computations can be done on the bottom portion of the record of fire.

e. The intermediate timer setting must be corrected for timer temperature in table K by entering with intermediate timer setting 22.2 and propellant temperature +56° F. Because VT is to be fired in this mission, a back-off time needs to be determined from table L by entering with a corrected timer setting and propellant temperature of +56° F. Complete computations with data to fire are shown in figure 13-34.

| RECORD OF FIRE                    |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
|-----------------------------------|--|--|--|--|--|--|--|--|--|----------|--|--|--|--|
| CALL FOR FIRE                     |  |  |  |  |  |  |  |  |  | △ F5     |  |  |  |  |
| Observer: _____                   |  |  |  |  |  |  |  |  |  | 100/R    |  |  |  |  |
| U/D: _____                        |  |  |  |  |  |  |  |  |  | /R       |  |  |  |  |
| Fz: _____                         |  |  |  |  |  |  |  |  |  | 20/R     |  |  |  |  |
| SI: _____                         |  |  |  |  |  |  |  |  |  | HOB Corr |  |  |  |  |
| FIRE ORDER                        |  |  |  |  |  |  |  |  |  | SI + 14  |  |  |  |  |
| INITIAL FIRE COMMANDS             |  |  |  |  |  |  |  |  |  | El 376   |  |  |  |  |
| To: _____                         |  |  |  |  |  |  |  |  |  | QE (390) |  |  |  |  |
| MTC                               |  |  |  |  |  |  |  |  |  | in Eff   |  |  |  |  |
| SUBSEQUENT FIRE COMMANDS          |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| Tgt Location Priority Firing Unit |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| Df Corr                           |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| DATA TO FIRE                      |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| TIMER                             |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| HOB F5                            |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| TBL O                             |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| INTERMEDIATE                      |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| TBL A                             |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| CORRECTED                         |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| TBL L                             |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| VT F5                             |  |  |  |  |  |  |  |  |  |          |  |  |  |  |
| (TO FIRE)                         |  |  |  |  |  |  |  |  |  |          |  |  |  |  |

Figure 13-34. Firing data.

## 13-12. Observer Adjustment Technique

Following is an example of the observer adjustment technique for delivery of the M454 nuclear projectile armed by the sequential timer M32E1 (fig 13-35). The target is located at grid 5954 3841, altitude 366.

a. The following call for fire is received from an FSO for engagement with shell M454. The call for fire and fire order commands are recorded on the record of fire. The propellant temperature is +9° F.

b. No valid GFT setting or met data is available.

c. The observer will be notified by secure message to adjust on the grid received in the call for fire and that the fire for effect will be with M454.

d. Completed initial fire commands, observer corrections, and subsequent fire commands for shell HE are recorded in figure 13-35.

e. When the observer corrects HE/TI to a 20-meter HOB, he requests FFE. Final HE data is determined, then an additional site

## RECORD OF FIRE

|                                                                      |          |          |             |                 |         |      |          |             |          |                         |          |                 |     |            |     |      |
|----------------------------------------------------------------------|----------|----------|-------------|-----------------|---------|------|----------|-------------|----------|-------------------------|----------|-----------------|-----|------------|-----|------|
| CALL FOR FIRE                                                        |          |          |             |                 |         |      |          |             |          | TGT ALT 366             |          | △ FS . 11       |     |            |     |      |
| Observer _____ AF/FFE/IS/S _____ Tgt _____                           |          |          |             |                 |         |      |          |             |          | WPN ALT 348             |          | 100/R 18        |     |            |     |      |
| Grid: _____                                                          |          |          |             |                 |         |      |          |             |          | VI +18                  |          | /R              |     |            |     |      |
| Polar: Dir _____ Dis _____ U/D _____ VA _____                        |          |          |             |                 |         |      |          |             |          |                         |          | 20/R 4          |     |            |     |      |
| Shift _____ Dir _____ L/R _____ +/- _____ U/D _____                  |          |          |             |                 |         |      |          |             |          | Si ÷ 10                 |          | 10m Si          |     |            |     |      |
| HOB Corr                                                             |          |          |             |                 |         |      |          |             |          |                         |          |                 |     |            |     |      |
| FIRE ORDER                                                           |          |          |             |                 |         |      |          |             |          | Df Corr 0               |          | Si +4           |     |            |     |      |
| INITIAL FIRE COMMANDS FM MF #1                                       |          |          |             |                 |         |      |          |             |          | Rg 5680                 |          | Chf Df 3327     |     | EI 348     |     |      |
| Sp Instr _____ Sh _____ Lot _____                                    |          |          |             |                 |         |      |          |             |          | Chg 4 Fz _____ Ti _____ |          | Df 3327         |     | QE 352     |     |      |
| MTO: ADJUST ON GRID 2954384, NUC<br>/e, REPORT WHEN READY TO OBSERVE |          |          |             |                 |         |      |          |             |          | PER _____ TF _____      |          | ① NUC Ti in Eff |     | Ammo Exp ① |     |      |
| SUBSEQUENT FIRE COMMANDS                                             |          |          |             |                 |         |      |          |             |          |                         |          |                 |     |            |     |      |
| Tgt                                                                  | Location | Priority | Firing Unit | MF, Sh, Chg, Fz | FS Corr | Ti   | Chart Df | Df Corr (O) | Df Fired | Chart Rg                | HOB Corr | Si (+/-)        | EI  | QE         | Exp | Type |
| Dir MF Sh, Fz                                                        | Dev      | Rg       | HOB Corr    |                 |         |      |          |             |          |                         |          |                 |     |            |     |      |
| 250                                                                  | R30      | -400     |             |                 |         |      | 3324     | 0           | 3324     | 5280                    | +4       | 316             | 320 | ②          |     |      |
|                                                                      |          | +200     |             |                 |         |      | 3324     | 0           | 3324     | 5480                    | +4       | 332             | 336 | ③          |     |      |
|                                                                      |          | -100     |             |                 |         |      | 3325     | 0           | 3325     | 5380                    | +4       | 324             | 328 | ④          | Q   | ✓    |
|                                                                      |          | +50      |             | FZ Ti           |         | 19.8 | 3325     | 0           | (3325)   | 5440                    | +4       | +8              | 329 | 337        | ①   |      |

|                          |          |          |             |                   |         |      |          |             |          |              |          |          |     |       |     |      |  |
|--------------------------|----------|----------|-------------|-------------------|---------|------|----------|-------------|----------|--------------|----------|----------|-----|-------|-----|------|--|
| SUBSEQUENT FIRE COMMANDS |          |          |             |                   |         |      |          |             |          |              |          |          |     |       |     |      |  |
| Tgt                      | Location | Priority | Firing Unit | MF, Sh, Chg, Fz   | FS Corr | Ti   | Chart Df | Df Corr (O) | Df Fired | Chart Rg     | HOB Corr | Si (+/-) | EI  | QE    | Exp | Type |  |
| Dir MF Sh, Fz            | Dev      | Rg       | HOB Corr    |                   |         |      |          |             |          |              |          |          |     |       |     |      |  |
| T1                       |          | +50      |             | FZ Ti             |         | 19.8 | 3325     | 0           | (3325)   | 5440         | +4       | +8       | 329 | 337   | ①   | Ti   |  |
|                          |          |          | UTO FFE     | SH NUC LOTQE -0.1 |         | 19.7 |          |             | (3325)   |              | +2       | +10      | 329 | (339) | HE  | DATA |  |
|                          |          |          |             | CHG 1 FZ Ti       |         | 20.7 |          |             | 3329     |              |          |          |     | 359   |     |      |  |
| TIMER                    |          |          |             |                   |         |      |          |             |          | DEFLECTION   |          |          |     |       |     |      |  |
| M564 FS 19.7             |          |          |             |                   |         |      |          |             |          | HE OF 3325   |          |          |     |       |     |      |  |
| TBL O +1.1               |          |          |             |                   |         |      |          |             |          | TBL O L4     |          |          |     |       |     |      |  |
| INTERMEDIATE FS 20.8     |          |          |             |                   |         |      |          |             |          | NUC QE 3329  |          |          |     |       |     |      |  |
| TBL K -0.1               |          |          |             |                   |         |      |          |             |          |              |          |          |     |       |     |      |  |
| PREP TEMP +9°F           |          |          |             |                   |         |      |          |             |          |              |          |          |     |       |     |      |  |
|                          |          |          |             |                   |         |      |          |             |          | HOB CORR     |          |          |     |       |     |      |  |
|                          |          |          |             |                   |         |      |          |             |          | HE HOB +20   |          |          |     |       |     |      |  |
|                          |          |          |             |                   |         |      |          |             |          | NUC HOB +30  |          |          |     |       |     |      |  |
|                          |          |          |             |                   |         |      |          |             |          | HOB CORR +10 |          |          |     |       |     |      |  |
|                          |          |          |             |                   |         |      |          |             |          | 10/R F 2     |          |          |     |       |     |      |  |

Figure 13-35. Observer adjustment technique.

correction is made for the desired nuclear HOB by applying an HOB correction to the last site fired. The HE data is corrected in the same manner as with the K-transfer technique to determine nuclear data to fire.

*Note.* Enter table O with HE QE, table K with intermediate timer setting and propellant temperature, and table L (if VT is used) with corrected timer setting and propellant temperature.

### 13-13. FADAC Procedures

a. The FADAC computation of firing data for the M454 nuclear projectile is accomplished using the same techniques discussed for manual procedures.

b. Special considerations for each technique are as follows:

(1) *Met correction.* This technique should be used when accurate location of gun and target, and current met are available. If a loss in velocity based on wear or EFC rounds for erosion is known, it should be applied to the standard nuclear muzzle velocity. The answer is the MV input. As with the manual procedures, the only HE residual that will be used is the deflection correction. A nuclear HOB must be entered prior to computation.

(2) *K-transfer.* This technique is used when current met data is not available, but current registration corrections are available. The FADAC registration corrections must be based upon standard met to determine the residuals. To insure that FADAC applies the registration corrections, they must be entered after the projectile and fuze for the nuclear round have been entered.

If the registration was conducted with a standard HE muzzle velocity, a standard muzzle velocity would be used for the nuclear round. The HE residuals (df, ti, and rg K) from the registration must be applied to the standard nuclear muzzle velocity by entering them into FADAC before computing firing data.

(3) *Observer adjustment.* This is the least desirable technique and is used when

neither current met nor registration corrections are available. Unlike manual procedures, the observer does not adjust fuze time. This is not necessary because FADAC will not transfer HOB corrections from fuze time to the sequential timer for the nuclear round. When the observer announces fire for effect, FADAC replot procedures must be done to obtain an accurate target location and altitude.



# CHAPTER 14

## EMERGENCY FDC PROCEDURES

### Section I. BATTERY EMERGENCY MISSIONS

Field artillery units must be capable of delivering fire at all times. Requests for immediate fires may be received when the unit is moving, or when the FDC is not yet set up. The loss of personnel or equipment may cause the battery to rely on some type of emergency backup procedures. The firing battery executing an emergency fire mission has two priority technical fire direction tasks:

- a. Determine initial firing data to the target.
- b. Prepare for determination of subsequent data based on the observer's corrections.

#### 14-1. Methods of Determining Initial Data

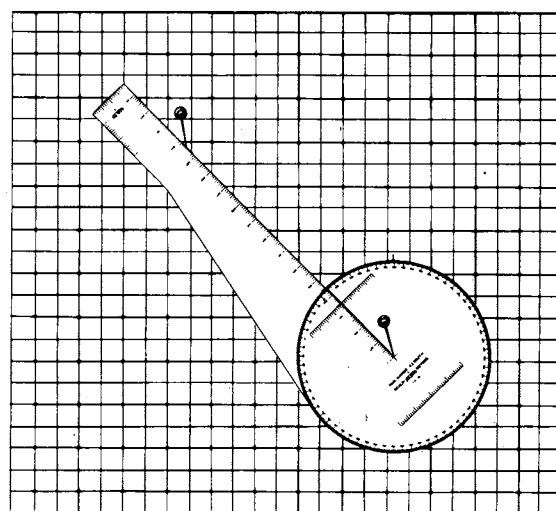
The first priority is to compute initial data, announce it to the piece, and fire a round. Depending on the call for fire, the executive officer or FDC may accomplish this using one of several methods:

a. *Adjust Fire.* The executive officer (FDC) determines *direction* and *range* to the target grid location from the map-spotted battery location. This is accomplished most rapidly using a map and a *range-azimuth fan* of the correct scale (fig 14-1). The executive officer directs that the battery be laid on the azimuth to the target, or he may orient the base piece himself using the howitzer backlay method or

a distant aiming point. The executive officer (FDC) selects a charge, or uses the standard charge, and converts the range to an *elevation*. The initial firing data is announced to the piece.

Df: Common deflection for weapon system.

QE: Elevation corresponding to range to target (GFT, TFT, etc.). Site is ignored unless it is excessively large.



AZIMUTH 5600m  
RANGE 13,700 METERS

Figure 14-1. Range-azimuth fan.

*b. Mark Center of Sector.* This is requested when the observer is not oriented on the ground. The executive officer (FDC) determines *direction* and *range* to the center of the supported unit's zone of action from the map-spotted battery location. If the executive officer is not sure of the situation or the location of the sector center, or if he feels a center of sector round may be unsafe, a white phosphorus/time high airburst should be fired. The executive officer directs that the battery be laid on the azimuth he determines to the sector center. The executive officer (FDC) determines the *elevation* corresponding to the range and charge. The initial firing data is announced to the piece.

(1) For a WP or HE high airburst, the trajectory is raised to a 200-meter height of burst using the 100/R factor. The FS M564 time corresponding to the initial elevation is used. The error introduced by a vertical interval greater than 100 meters is ignored.

(2) If shell smoke or WP is requested, HE data is fired without making corrections for projectile weight. For shell smoke, the time fuze setting to fire is determined by subtracting 2 seconds from the FS M564 time corresponding to the HE elevation.

A GRID LOCATION IS PREFERRED OVER MARK CENTER OF SECTOR BECAUSE THE FIRST ROUND FIRED ENGAGES THE TARGET DIRECTLY.

#### 14-2. Methods of Determining Subsequent Data

After the initial fire commands are announced, emergency equipment must be prepared to convert the observer's corrections into subsequent fire commands. There are several expedient means of obtaining subsequent data available to the executive officer. He or the FDO must be able to convert observer corrections into firing data quickly.

*a. Emergency Firing Chart.* Use of the emergency firing chart to adjust fire is discussed in section II.

★ *b. M10/M17 Plotting Board.* Use of the M10, M17, or the M16 mortar board (fig 14-2) to adjust fire is discussed in section III.

★ *c. Black Magic.* If no other means of adjusting fire is available, the black magic technique may be used as a last resort. Certain information must be available, as detailed in table 14-1.

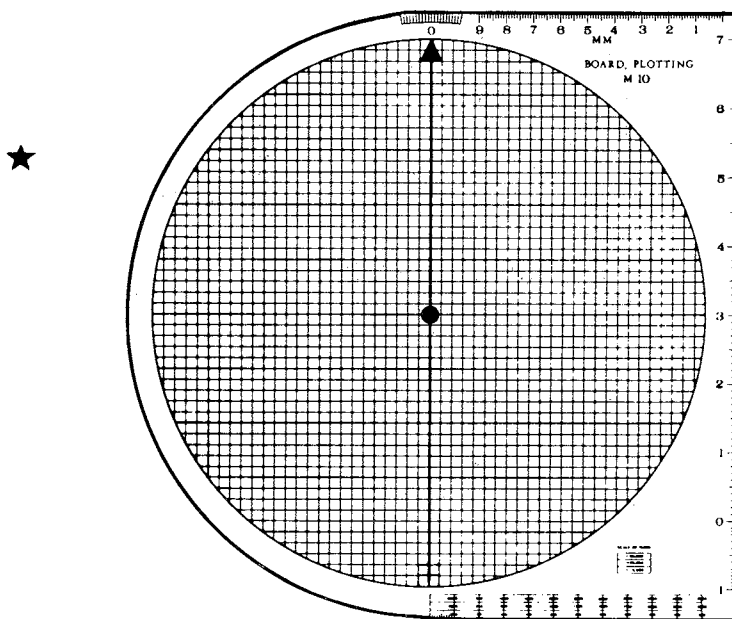


Figure 14-2. M10 plotting board.

Table 14-1. Black Magic Technique

| WEAPON<br>SYSTEM          | R                  | CHG | C<br>FACTOR | INITIAL<br>QE | 100/R        |
|---------------------------|--------------------|-----|-------------|---------------|--------------|
| 105-MM<br>M101A1          | RANGE<br>IN 1000's | R+1 | 13-CHG      | 240           | $100 \div R$ |
| 105-MM<br>M102            | RANGE<br>IN 1000's | R+1 | 12-CHG      | 240           | $100 \div R$ |
| 155-MM<br>M114A1          | RANGE<br>IN 1000's | R   | 12-CHG      | 240           | $100 \div R$ |
| 155-MM<br>M109/<br>M114A2 | RANGE<br>IN 1000's | R   | 11-CHG      | 240           | $100 \div R$ |
| 155-MM<br>M109A1          | RANGE<br>IN 1000's | R   | 11-CHG      | 240           | $100 \div R$ |
| 8-INCH<br>M110/<br>M110A1 | RANGE<br>IN 1000's | R-1 | 10-CHG      | 240           | $100 \div R$ |

THE "BLACK MAGIC" TECHNIQUE IS VALID FOR  
ONLY CHARGES 3, 4, AND 5 OF THE LISTED  
WEAPONS SYSTEMS

CONDUCT A GUN-TARGET LINE ADJUSTMENT  
COMPUTE SUBSEQUENT DATA:

- ① LATERAL DEVIATION IN HUNDREDS OF  
METERS, TO NEAREST 10 METERS  
 $\times 100/R$  AT INITIAL ESTIMATED RANGE  
= CORRECTION TO PREVIOUS DEFLECTION  
IN MILS
- ② RANGE CHANGE IN HUNDREDS OF  
METERS  
 $\times C$  FACTOR = CORRECTION TO  
QE IN MILS
- ③ TIME FUZE:  
APPLY  $20/R$  TO QE  
ESTIMATE INITIAL FUZE SETTING  
ADJUST HOB ARBITRARILY

★ ④  $\Delta FS = 2 \div FS$

## Section II. BATTERY EMERGENCY CHARTS

### 14-3. Description

a. The *emergency firing chart* employs the same basic technique as observed firing charts: establishing location and direction using the relationship between the battery and its targets. The relationship is determined by firing and will contain shot-in errors. The emergency chart is only a temporary expedient to be used until a surveyed chart can be constructed.

b. The emergency chart may be constructed on any surface suitable for plotting that can accommodate an RDP and plotting pins.

### 14-4. Construction of an Emergency Chart

a. The procedures below are followed to construct an emergency chart and prepare for subsequent corrections.

b. Assume the following situation occurs: The call for fire below has been received. The initial data, as shown in figure 14-3 has been determined and sent to the cannon sections.

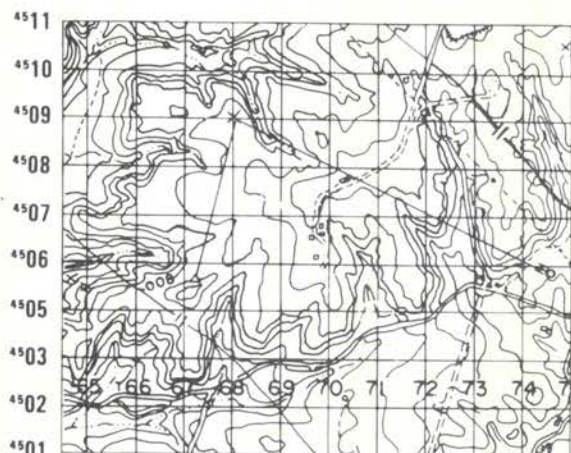
(1) Set the RDP down in the middle of the plotting surface. Orient the RDP in the general direction of fire (top of chart is north). Place a pin in the vertex to represent the battery center.

(2) Place a pin opposite the appropriate common deflection graduation along the arc of the RDP to represent the primary deflection index (fig 14-4).

(3) Slide the cursor to the elevation on the GFT fan fired initially and place a pin opposite the hairline. (Place the pin opposite the range to target or center of sector on the RDP.) This pin represents the location of the initial round fired (fig 14-5).

**THE ELEVATION OR RANGE USED TO COMPUTE THE INITIAL DATA MUST BE USED TO CONSTRUCT THE EMERGENCY CHART.**

(4) Center a target grid over the target pinhole, alining the 0-3200 line with the left edge of the GFT fan (RDP) (fig 14-6). The arrow on the target grid should face away from the vertex, in the direction of fire.



#### SITUATION:

BATTERY MOVING IN GRID 7405  
CALL FOR FIRE FROM OBSERVER AT 672056

MARK CENTER OF SECTOR

OR

ADJUST FIRE GRID 6809

STANDARD CHARGE IS 6

AZIMUTH 5260  $\mu$  DEFLECTION 3200  
RANGE 7300M QUADRANT 272

DIRECTION 250 $\mu$

Figure 14-3. Situation data.

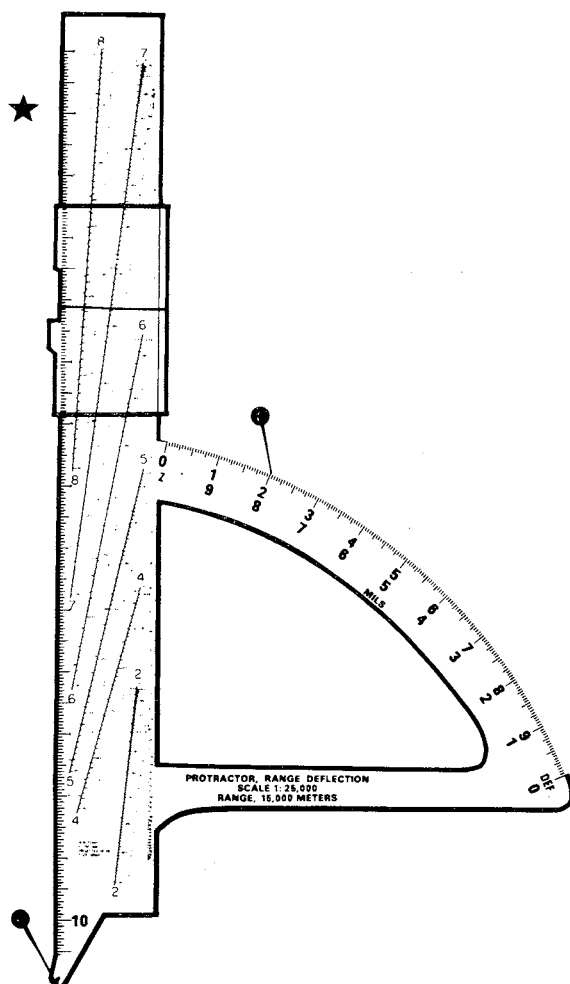


Figure 14-4. Primary deflection index.

(5) Place a pin opposite the graduation on the scale of the target grid corresponding to the azimuth of lay. The location of the pin represents grid north with respect to the azimuth of fire, and is used as the north index. It may be necessary to move the RDP in order to place the pin.

(6) Rotate the target grid until the graduation corresponding to the announced observer-target direction is opposite the north index pin (fig 14-7). The target grid is now properly oriented to plot the observer's subsequent corrections. Angle T can be read off the target grid, under the GFT fan. Construction of the emergency firing chart is complete.

c. If the emergency chart is to be used for

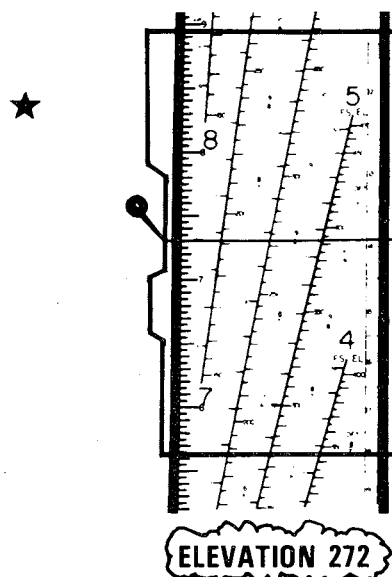


Figure 14-5. Pin location of initial round.

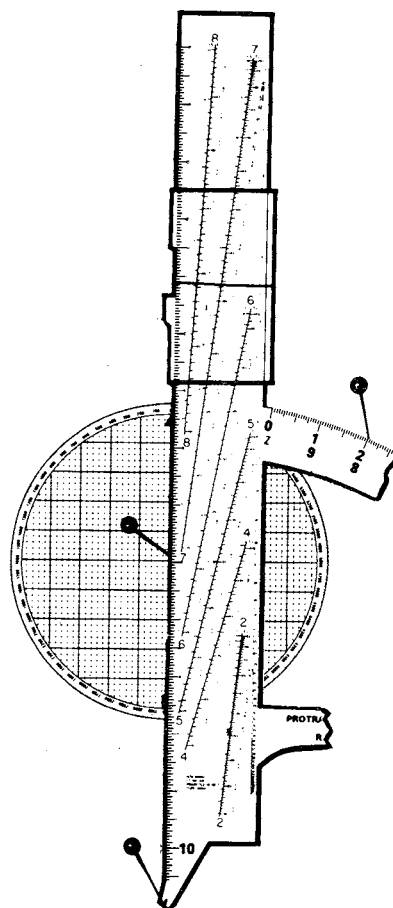


Figure 14-6. Centered target grid.

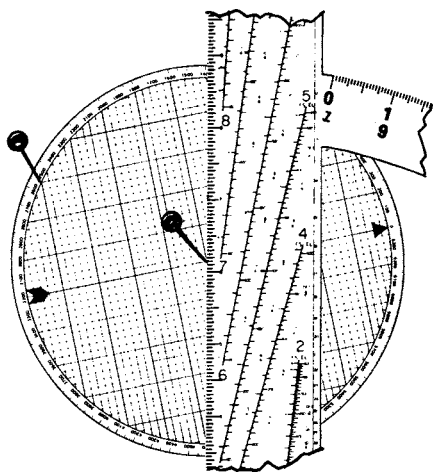


Figure 14-7. Oriented target grid.

subsequent missions, the final pin location for each target may be tick-marked and a north index constructed.

- (1) Place center of target grid over final pin location.
- (2) Realine 0-3200 line with left edge of GFT fan (RDP).
- (3) Convert final deflection to azimuth.
- (4) Construct north index opposite final azimuth.

This allows future target locations to be sent by shift from a known point. Deflection indexes will be established.

d. If the battery will not displace immediately, FDC should transfer to a surveyed chart as soon as possible. Such a chart will usually be based on a map spot location. The emergency chart should be replaced as soon as possible.

e. Targets that were established by the FO and the FDO as known points are replotted from the emergency chart to the map spot or survey chart using standard replot procedures. This should be accomplished as soon as corrections for nonstandard conditions become available.

#### Example:

*Situation.* Battery B, an M109A1 (155-mm) unit, is habitually in support of

an armor-heavy team moving in bounding overwatch to an intermediate objective. The team has moved far enough to require that Battery B displace forward to a new position. One of the battery platoons is on the road when the following call for fire is received:

**Z16 THIS IS Z17, FIRE MISSION, GRID 147426, INFANTRY IN BTR-60s, ICM IN EFFECT, OVER.**

The other two platoons of the battery are already engaged. The displacing platoon, therefore, occupies an emergency position to deliver supporting fires. Current standards are shown in table 2.

Lot X is HE

Lot W is WP

Lot S is GB

Battery SOP further specifies that the initial round to be fired will be *shell WP, fuze time, 200 meters HOB*.

The chief of firing battery (CFB) moving with the platoon has determined center of sector data as *direction to center of zone = 1700 mils; range to center of sector = 6000 meters*.

Based on the observer's call for fire, current standards, unit SOP, and the direction and range determined, the CFB tells the "jump" FDC computer to determine data based on *shell WP, lot WS, charge 4, fuze time, two rounds HE, VT in effect*.

The CFB then transmits the message to observer:

**D62, HE, VT IN EFFECT, TWO ROUNDS, OVER.**

The battery is laid on azimuth 1700. The jump FDC computer determines and announces initial fire commands, and the initial rounds are fired.

Time (fuze setting corresponding to range 6000) ..... 22.4

Deflection (the common deflection is fired) ..... 3200

Quadrant elevation ..... 410

Table 14-2. Fire Order and Fire Command Standards

| FIRE ORDER STANDARDS                                         |                                |
|--------------------------------------------------------------|--------------------------------|
| ELEMENT                                                      | CURRENT STANDARD               |
| UNIT TO FIRE                                                 | BTRY                           |
| ADJUSTING ELEMENT/<br>METHOD OF FIRE OF ADJUSTING<br>ELEMENT | # 4 ①                          |
| BASIS FOR CORRECTION                                         | FASTEST METHOD                 |
| DISTRIBUTION                                                 | PARALLEL SHEAF                 |
| PROJECTILE                                                   | HE                             |
| AMMUNITION LOT AND CHARGE                                    | XS, 4                          |
| FUZE                                                         | Q                              |
| NUMBER OF ROUNDS                                             | ①                              |
| RANGE SPREAD, LATERAL<br>SPREAD, ZONE FIRE, OR<br>SWEEP FIRE | CENTER RANGE AND<br>DEFLECTION |
| TIME OF OPENING FIRE                                         | WHEN READY                     |

| FIRE COMMAND STANDARDS                            |                                     |
|---------------------------------------------------|-------------------------------------|
| ELEMENT                                           | STANDARD ELEMENTS<br>BY CURRENT SOP |
| WARNING ORDER                                     |                                     |
| PIECES TO FOLLOW/PIECES<br>TO FIRE/METHOD OF FIRE | # 4 ①                               |
| SPECIAL INSTRUCTIONS                              |                                     |
| PROJECTILE                                        | HE                                  |
| AMMUNITION LOT                                    | XS                                  |
| CHARGE                                            |                                     |
| FUZE/FUZE SETTING                                 | Q                                   |
| DIRECTION                                         |                                     |
| QUADRANT ELEVATION                                |                                     |
| METHOD OF FFE                                     |                                     |

Elevation corresponding to  
range 6000 ..... 376  
+200/R ..... +34  
= 410

Note. Site and ballistic corrections for shell WP  
are ignored.

The computer now begins the construction of  
an emergency firing chart to convert the  
observer's corrections to firing data.

(1) Place the RDP on the plotting surface  
and a pin at the vertex to represent battery  
center.

(2) Place a pin opposite the common deflection graduation along the arc of the RDP (fig 14-8).

(3) Place a pin opposite the range to the target.

(4) Center the target grid over the pinhole established at range 6000. Aline the 0-3200 line of the target grid with the left edge of the RDP. The arrow of the target grid should face away from the vertex of the RDP.

(5) Place a pin opposite the graduation on the target grid corresponding to the azimuth of lay (1700 mils) (fig 14-9). The pin now represents a grid north index.

(6) Rotate the target grid until the announced OT direction (2400) is opposite the north index. The observer's corrections can now be plotted and converted to firing data by standard manual procedures.

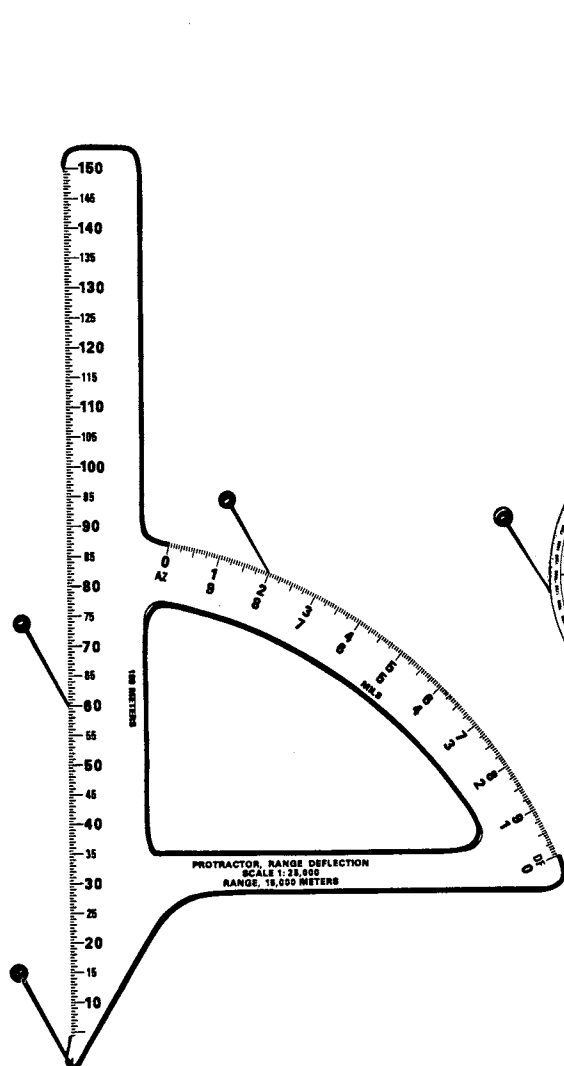


Figure 14-8. Common deflection position.

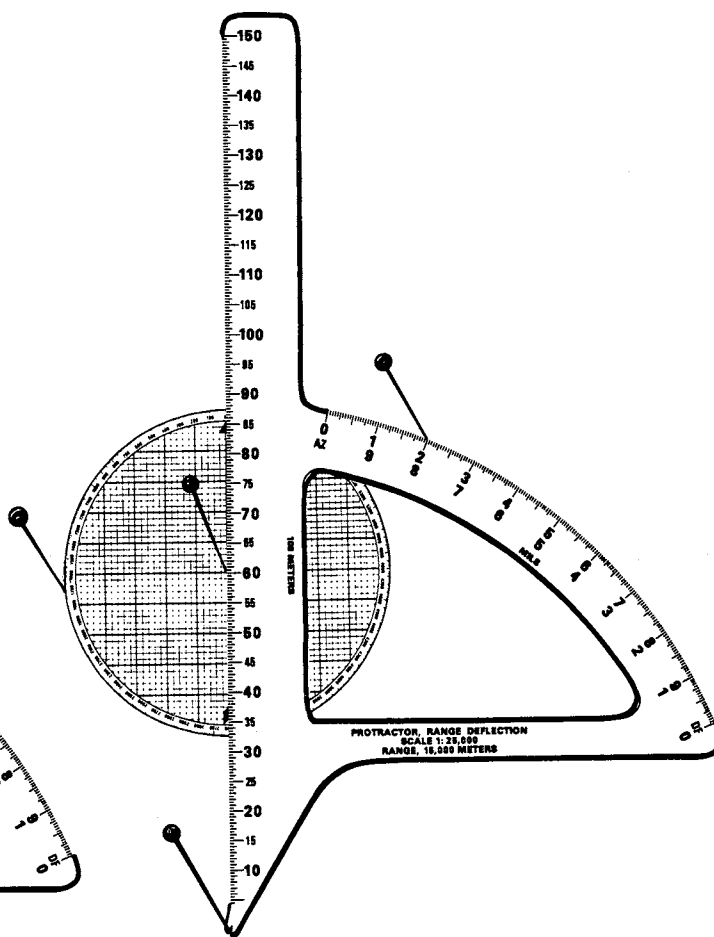


Figure 14-9. Representation of a grid north index.



## Section III. M10/M17 PLOTTING BOARD

The M10/M17 plotting board may be used for determining data for subsequent corrections in place of an emergency chart. Once prepared, observer corrections along the observer-target line can be converted to corrections along the gun-target line.

### 14-5. Preparation of the Plotting Board for Use

The executive officer prepares the plotting board for use by placing a mark labeled "O" on the rotating disk opposite the number representing the OT direction. Then, he places a mark labeled "G" opposite the number representing the GT direction. The outer black scale on the disk is used for this purpose.

FO: Direction 1200

XO: Direction to tgt (GT dir) 1700

When the "O" is opposite the red arrow at the top of the plotting board, the board is in the "OT position." When the "G" is opposite the red arrow, the board is in the "GT position" (fig 14-10).

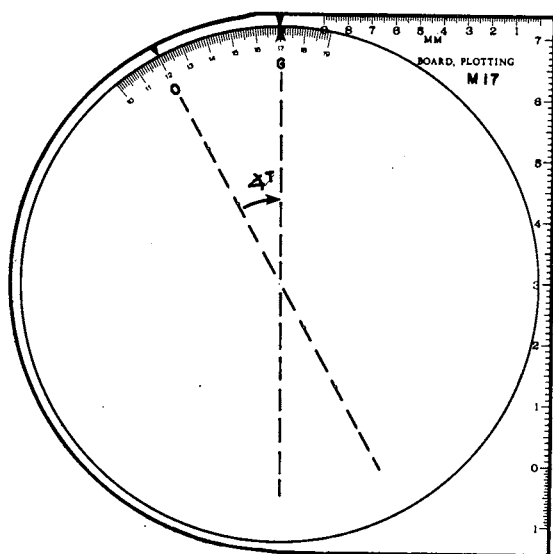


Figure 14-10. GT position.

*Note.* Angle T is represented by the angle formed by the OT direction and the GT direction.

### 14-6. Subsequent Corrections

After the impact of the first round, the observer sends the deviation and range correction (LEFT or RIGHT; ADD or DROP) to adjust onto the target. His corrections are based on the observer-target direction that he has specified in his call for fire. The executive officer must convert these OT corrections into corrections with respect to the gun-target line. This conversion is accomplished by means of the plotting board.

#### a. Converting OT Corrections to GT Corrections.

(1) The observer sends his deviation and range correction from the burst of the round to the target.

(2) The executive officer places the plotting board in the "OT position." On the plotting board, the center of the disk represents the point at which the last round burst. All observer corrections are plotted from that point. Most shifts can be plotted when each small red square of the board represents 10 or 20 meters; any convenient scale can be used, as long as it is consistently used.

(3) The executive officer plots the observer's corrections and marks the plot as shown in figure 14-11.

FO: RIGHT 120, DROP 200

(4) The executive officer now rotates the disk to the "GT position." Now that the disk is in the "GT position," the shift with respect to the GT line can be measured from the center point of the board to the tick mark. The measurement is the deviation and range correction with respect to the GT line (GT corrections) as shown in figure 14-12.

GT correction: RIGHT 290, DROP

300

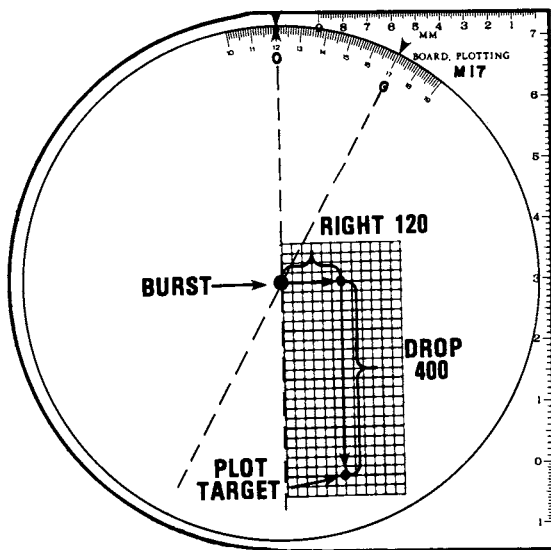


Figure 14-11. Observer's corrections.

*b. Conversion of GT Corrections into Firing Data.*

(1) *Converting the GT deviation correction into deflection.* To determine the new df to be fired, the executive officer converts the GT deviation correction from meters into mils and then applies the result to the last deflection fired as follows:

(a) Determine the value of  $100/R$  for the initial range to the target by dividing 100 by

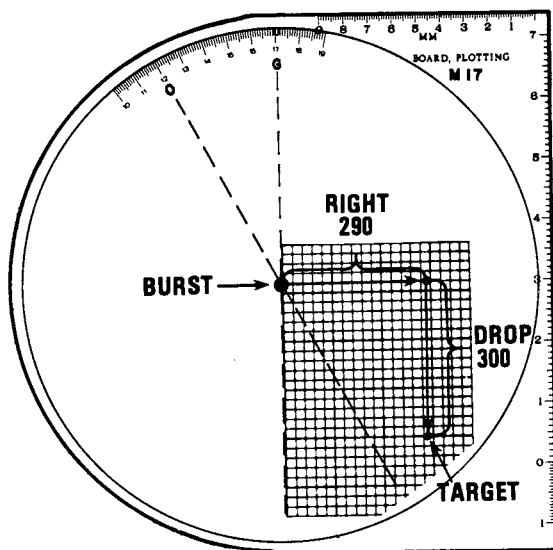


Figure 14-12. GT correction.

the initial chart range expressed to the nearest 1000 or reading it from the GFT.

(b) Multiply  $100/R$  by the GT deviation correction and divide by 100.

$$\frac{100}{R} \times \frac{\text{GT dev corr}}{100} = \text{df change}$$

$$16 \times \frac{\text{right 290}}{100} = \text{right 46 mils}$$

The result is the GT deviation correction in mils (df change) which is then applied using the LARS rule to the last deflection fired. The result is the new deflection to be fired.

$$\begin{aligned} \text{Last df fired} &= 3300 \\ \text{Last df fired} + \text{df change} &= \text{new df} \\ 3300 + \text{right 46} &= 3254 \text{ mils} \end{aligned}$$

XO to guns: **DEFLECTION 3254.**

(2) *Converting the GT range into quadrant.*

(a) To determine the new QE to be fired, the executive officer must apply the GT range correction to the last range fired.

$$\begin{aligned} \text{Last range} & \\ \text{fired} + \text{GT rg corr} &= \text{new rg} \\ 6440 \text{ meters} + (\text{drop 300}) &= 6140 \text{ meters} \end{aligned}$$

(b) The new range is set off on the GFT (or used to enter the TFT) and the new elevation is extracted. Site is applied, as appropriate. The result is the quadrant to be fired.

$$\begin{aligned} \text{El 388} + \text{si} &= \text{QE 388} \\ \text{XO to guns: } &\mathbf{QUADRANT 388.} \end{aligned}$$

(3) *Plotting board.* Once the firing data has been determined and checked, the executive officer clears the plotting board of the observer corrections (tick mark). When new corrections are received, the conversion process is repeated.

*Example:*

a. The FDC and BOC of a 155-mm M109A1 battery have been destroyed along with all of their equipment. The battery executive officer has a map, a plotting board, a GFT and TFT, and a protractor. He receives the following call for fire from the observer:

FOR THIS IS X19. ADJUST FIRE,  
OVER.  
GRID 217 819 OVER  
ENEMY TANK PLATOON, OVER.

The executive officer plots on the map his battery location and the target location sent by the observer. Using his protractor, he measures the direction (azimuth) and the range to the target. The observer sends his OT direction.

GT direction: 5810 mils.

GT range: 6320 meters.

OT direction: 4800 mils.

b. The executive officer knows that his battery is laid at an azimuth of 5600 mils and the common deflection for an M109A1 is 3200 mils. Deflection to be fired is determined as follows:

Az of lay (5600 mils) → az to tgt (5810 mils) = right 210 mils

(As azimuth increases, deflection decreases.)

Common df of 3200 mils + right 210 mils = 2990 mils.

XO to the guns: **DEFLECTION 2990 mils.**

The initial quadrant to be fired is determined as follows: (By inspection of the map, the executive officer determines that the difference in altitude between the battery and the target is less than 100 meters; therefore, he makes site = 0.)

XO selects charge 4

GFT

El ~ rg 6320 = 406

or

TFT by interpolation

El ~ rg 6320 = 406

El + si = QE

406 + 0 = quadrant 406

XO to guns: **QUADRANT 406.**

c. The executive officer prepares his plotting board for subsequent observer corrections and determines 100/R. From the GFT, he reads 100/R = 16.

Computing manually

$$\frac{100}{\text{rg (in 1000s)}} = \frac{100}{6.3} = 16 \text{ mils}$$

d. The observer sends his first correction and the executive officer uses the plotting board to determine GT corrections:

RIGHT 200, ADD 200

The executive officer determines GT corrections to be:

LEFT 60, ADD 280

He proceeds to determine the df to be fired.

$$\frac{100}{R} \times \frac{\text{GT dev corr}}{100} =$$

$$16 \times \text{LEFT 60} = \text{LEFT 9.6} \rightarrow \text{LEFT 10 mils}$$

$$\begin{array}{rcl} 100 & & \\ \text{1st df} + \text{df change} & = & \text{new df to be fired} \\ 2990 \text{ mils} + \text{LEFT 10 mils} & = & 3000 \text{ mils} \end{array}$$

Df to be fired is 3000 mils

He then applies the GT range correction and determines the new QE to be fired.

Last range + GT rg corr = new rg to be fired

$$6320 \text{ meters} + (\text{ADD 280}) = 6600 \text{ meters}$$

$$\text{El} \sim 6600 \text{ meters} = 433 \text{ mils}$$

$$\text{El} + \text{Si} = \text{QE}$$

$$433 + 0 = \text{quadrant 433}$$

e. The round is fired and the observer sends another correction:

**LEFT 40, DROP 50, FIRE FOR EFFECT**

f. The executive officer uses the plotting board to determine the GT corrections:

XO GT corr: RIGHT 20, DROP 60

He determines the df to be fired.

$$\frac{100}{R} \times \frac{\text{GT dev corr}}{100}$$

$$16 \times \frac{\text{RIGHT 20}}{100} = \text{RIGHT 3.2} \rightarrow \text{RIGHT 3 mils}$$

$$\text{Last df (3000)} + \text{df change} = 3000 \text{ mils} + \text{R3 mils} = \text{df 2997 mils}$$

Then determines the quadrant to be fired:

$$\text{Last rg} = 6600 \text{ meters} + \text{rg corr}$$

$$(\text{DROP 60}) = 6540 \text{ meters}$$

$$\text{El} \sim 6540 = \text{El 427}$$

$$\text{El} + \text{Si} = 427 + 0 = \text{QE 427}$$

## Section IV. FADAC

### 14-7. FADAC Emergency Procedures

a. The M18 gun direction computer, FADAC, uses assumed data and basic procedures similar to the manual emergency chart. Its one advantage is that it uses all available nonstandard conditions in the computations. The key to using the FADAC for emergency missions is the entry of all possible information before displacement. When the battery grid location is unknown, it may be entered as grid 00. All known nonstandard conditions would be entered. The azimuth and range to the target must still be determined manually, but FADAC can locate the target using this data (polar plot from the battery) and the data can be computed.

b. If subsequent firing is anticipated, and time does not permit immediate transfer to surveyed input, refine and store the target to establish a known point. The grid stored will be valid only in its relation to the assumed

battery grid of 00. Perform MANUAL replot of the target to obtain its location when transferring to surveyed input.

c. The use of FADAC for emergency firing is recommended only in situations where the initial data will be determined prior to the guns being prepared to fire, or when no manual means are available. An example might be a hasty occupation, when survey is not available and fire mission is expected within several minutes.

d. When the initial data is manually computed, as in paragraph 14-1, it is not recommended to use FADAC for subsequent data. Unless a two-plot, FADAC-derived GFT setting for the charge to be fired has been applied to the executive officer's graphical equipment prior to displacement, FADAC data will differ from that of the executive officer sufficiently to throw off the second round in adjustment.

# CHAPTER 15

# OBSERVED FIRING

# CHARTS

## Section I. INTRODUCTION

### 15-1. Definition

a. When survey control and maps are not available, delivery of indirect fires is possible using observed firing charts. An observed firing (OF) chart is a firing chart on which all batteries and targets are plotted relative to each other. These relative locations are established by firing. Observed firing charts are an expedient that should only be used under emergency conditions. Every attempt should be made to construct a surveyed firing chart as soon as possible. Since all locations are based on fired data, observed firing charts contain errors due to nonstandard conditions.

b. All observed firing charts are based on a registration. Once a registration is complete, the battery location is polar plotted from the registration point (normally assumed to be a grid intersection) using a direction based on the back azimuth of fire and a range corresponding to the adjusted elevation.

c. Because maps and survey are not available, altitudes cannot be accurately determined. When vertical interval, and therefore site, is assumed to be zero, a false range is introduced into the polar plot range. This inaccuracy can be reduced by attempting to determine the site. Site may be determined by estimating vertical interval or by conducting an executive's high burst.

### 15-2. Methods of Determining Polar Plot Data

All observed firing charts are constructed using polar plot data. The method for obtaining this data depends upon the type of registration conducted and whether site can be estimated or whether it is unknown.

a. Percussion plot is used when an impact registration has been conducted.

(1) When site is not known and cannot be estimated, the method is known as a *percussion plot, site unknown*.

(2) When vertical interval can be estimated, a site can be determined and inaccuracies reduced. This method is known as *percussion plot, VI estimated*.

b. Time plot is used when a time registration has been conducted.

(1) When site is not known, the method is known as *time plot, site unknown*.

(2) When site can be determined using an executive's high burst registration, the method is known as *time plot, site known*.

c. The general procedures for constructing an OF chart are listed below.

(1) Select a registration point in the center of the sector of fire that can be identified on the ground.

(2) Assign this point arbitrary grid coordinates and altitude. Plot it on the firing chart.

(3) Conduct a precision registration (fuze time, if possible) on the registration point with the battery using its emergency firing chart procedures (chap 14).

(4) Determine the adjusted data (to include orienting angle, if possible).

(5) From the adjusted data, determine direction (azimuth) and distance (range) from the registration point to the battery.

(6) Polar plot the battery center from the registration point.

d. The grid coordinates assigned to the registration point are completely arbitrary. A grid intersection is preferred for simplicity. For example, the registration point could be assigned grid coordinates 2000040000, altitude 400 meters (fig 15-1). The grid

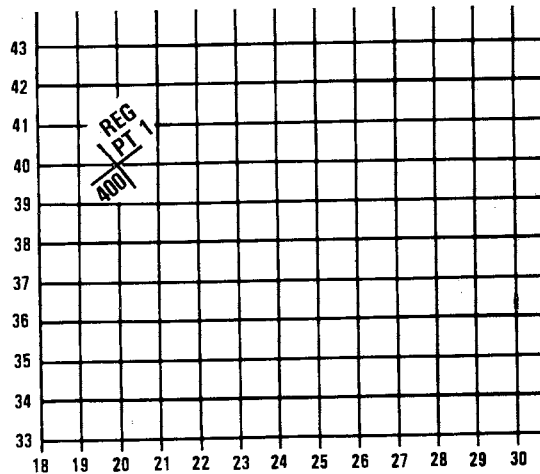


Figure 15-1. Establishing an observed fire chart grid.

coordinates of this registration point will serve as the basis for the establishment of a common grid system.

## Section II. BATTERY OBSERVED FIRING CHARTS

### 15-3. Determination of Direction for Polar Plotting

a. No matter what technique (percussion or time plot) is used, the direction (azimuth) of the battery from the registration point is computed in the same manner.

b. This direction is simply the back azimuth of fire to the registration point.

(1) If the battery has been laid magnetically, the adjusted azimuth of fire is measured magnetically.

(2) If an orienting line has been established and used to lay the battery, the orienting angle will be measured after the registration. The adjusted azimuth of fire is determined by subtracting the measured orienting angle from the azimuth of the orienting line. Although no maps are available, an orienting line can still be

established using simultaneous observation.

### 15-4. Percussion Plot, Site Unknown

a. The technique of percussion plot, site unknown is used to determine battery distance from the registration point and the battery altitude when an impact registration has been conducted.

b. Since no maps are available and an impact registration has been conducted, site cannot be determined or approximated. The percussion plot technique assumes that site is zero. The distance used to polar plot is the distance corresponding to the adjusted quadrant elevation.

Percussion plot, site unknown

Battery altitude = registration point altitude

Distance = range ~ adjusted quadrant elevation



**Example:**

A registration was conducted with charge 4GB. Site and battery altitude are unknown.

(1) The following data is known:

- (a) Adjusted QE 330
- (b) Azimuth of orienting line 1440
- (c) Measured orienting angle (after registration) 1820
- (d) Adjusted deflection 3241
- (e) Assumed altitude of registration point 400

(2) Determine the direction, altitude, and range from the registration point to the battery.

(a) *Direction of the battery from the registration point (fig 15-2).* This is accomplished by determining the azimuth of fire. Subtract the orienting angle measured after the registration from the azimuth of the orienting line. Add 6400 mils to the azimuth of the orienting line if necessary. The direction from the registration point to the battery is the back azimuth of the direction of fire.

|                                             |               |
|---------------------------------------------|---------------|
| Azimuth of the orienting line               | 1440          |
| Add 6400 mils                               | <u>+ 6400</u> |
|                                             | 7840          |
| Subtract the value of the orienting angle   | <u>- 1820</u> |
| Azimuth of fire                             | 6020          |
| Minus 3200 mils                             | <u>- 3200</u> |
| Polar plot direction (back azimuth of fire) | 2820          |

(b) *Battery altitude, 400 meters.* Site is unknown and no estimation of the vertical interval between the battery and the registration point has been made. The assumed altitude of the registration point becomes the battery altitude.

(c) *Distance of battery from registration point.* The polar plot distance is determined by placing the MHL over the adjusted QE and reading the corresponding range.

Rg ~ adj QE 330 = 5460 meters  
Battery center is 5460 meters from the

registration point along a direction of 2820 mils.

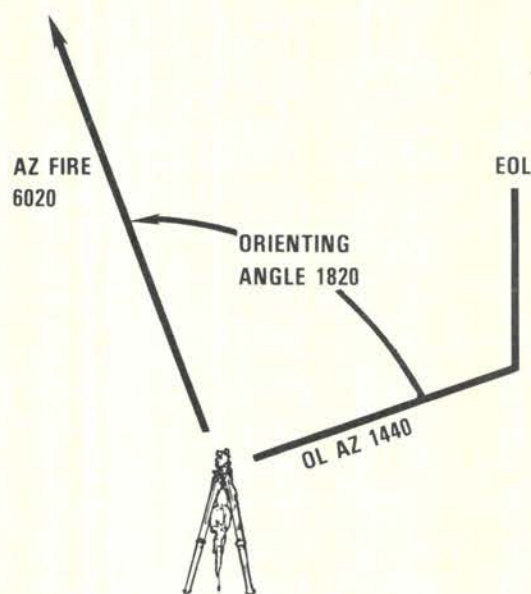


Figure 15-2. Direction of the battery from the registration point.

### 15-5. Percussion Plot, VI Estimated

a. When site is assumed to be zero, a large error can be introduced into the computation of range using the percussion plot technique. This error can be minimized and the accuracy of the chart improved by estimating a vertical interval between the battery and registration point. Battery altitude is then determined by subtracting the estimated vertical interval from the assumed altitude of the registration point.

b. This estimated vertical interval is then used to compute site in the following manner:

(1) A first apparent site for the battery is computed using the estimated vertical interval and the range corresponding to the battery's adjusted quadrant elevation.

(2) A first apparent adjusted elevation is derived by subtracting the first apparent site from the adjusted quadrant elevation.

(3) A second apparent site is computed using the same vertical interval and the range corresponding to the first apparent adjusted elevation. If this site is within 1 mil

of the previous site, the polar plot range is the required range corresponding to the first subsequent elevation.

(4) If the site varies by more than 1 mil from the previous site, successive approximation is continued until a site is determined that is within 1 mil of the previous site. The polar plot range is the range corresponding to the *last* derived adjusted elevation, which is determined using the final site computed.

Percussion plot, VI estimated

Battery altitude = registration point altitude - estimated VI. Site = estimated VI ÷ range ~ adj QE (use successive approximation).

Distance = range ~ last derived adjusted elevation.

**Example:**

Using the previous example, the vertical interval between the battery and registration point has been estimated to be +50 meters.

(1) Polar plot direction is determined as in paragraph 15-4.

(2) Battery altitude

|                                        |            |
|----------------------------------------|------------|
| Assumed altitude of registration point | 400 Meters |
| Minus estimated vertical interval      | - (+50)    |
| Estimated battery altitude             | 350 Meters |

(3) Polar plot distance requires determination of an estimated site to determine the adjusted elevation.

(a) Estimated vertical interval = +50

(b) Determine the initial range corresponding to the adjusted QE for use in the initial computation of site.

Range corresponding to QE 330 = 5460

(c) Compute the first apparent site.

First apparent site (+50 ÷ 5460, target above gun (TAG)) = +11

(d) Using the first apparent site, compute the first apparent elevation.

First apparent elevation (QE 330 - (+11)) = 319

(e) Determine the range corresponding to elevation 319. = 5320

(f) Using the same vertical interval and the new range, compute the second apparent site.

Site (+50 ÷ 5320, TAG) = +11

If the site is within 1 mil of the site previously computed, it is used to determine the adjusted elevation, which, in turn is used to determine the plot range.

(g) Determine the adjusted elevation.

Adjusted elevation (QE 330 - (+11)) = 319

(h) Polar plot range corresponds to the adjusted elevation.

Polar plot range at elevation 319 = 5320

(4) The introduction of an estimated vertical interval of +50 meters (fig 15-3) changes the determined range from the battery to the registration point by 140 meters (5460 - 5320).

#### 15-6. Time Plot, Site Unknown

a. Improved polar plot data can be determined by conducting a time registration. With the time registration, the FDC is assured that the burst occurred over the target. The adjusted time derived from the registration can be used to determine the true elevation and the actual range as in replot procedures. Because a true elevation can be determined, site may be derived (adj QE - true el) and a vertical interval determined.

b. The steps in this method are:

(1) A site may be derived by subtracting the elevation corresponding to the adjusted time (minus any known total fuze correction) from the adjusted QE.

(2) Range from the registration point to



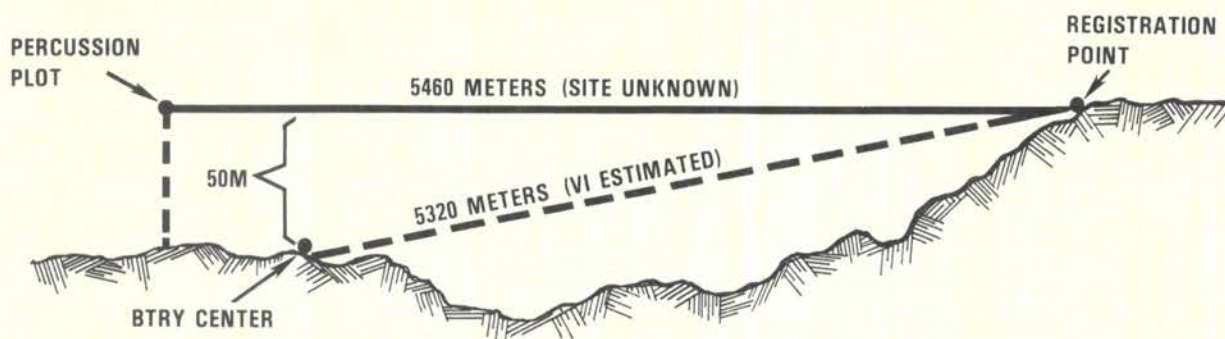


Figure 15-3. Difference in range resulting from difference in vertical interval.

the battery is determined at the range corresponding to the adjusted time.

(3) The vertical interval is determined using the graphical site table by multiplying the range from the registration point to the battery by the derived site.

(4) Battery altitude is computed by applying the vertical interval to the assumed altitude of the registration point.

(5) Elevation and time gagelines are constructed for the battery based on the plot data to the registration point.

Time plot, site unknown

True el = el ~ adj ti

Derived site = adj QE - true el

Polar plot range = range ~ adj ti

Computed VI = site  $\times$  polar plot range

Battery altitude = registration point altitude - computed VI

*Example:*

A 155-mm M109A1 howitzer battery has registered on a registration point using charge 4GB.

|                                                     |      |        |
|-----------------------------------------------------|------|--------|
| Adjusted QE                                         | 337  | mils   |
| Adjusted time                                       | 19.5 |        |
| Range corresponding to time 19.5 (polar plot range) | 5380 | meters |
| Elevation corresponding to time 19.5                | 324  | mils   |
| Derived site (337 - 324)                            | +13  | mils   |
| Vertical interval (+13 $\times$ 5380, chg 4, TAG)   | +60  | meters |
| Altitude of registration point (assumed)            | 400  | meters |

Altitude of battery  
(400 - 60)

340 meters

### 15-7. Determination of Site by Firing (Executive's High Burst)

a. The technique discussed in the previous paragraph is based on a rough approximation of site. This approximation can be refined to an accuracy approaching survey accuracy by the firing of a modified high burst registration after the completion of a precision registration with fuze time.

b. The objective of an executive's high burst is to determine precisely what portion of the adjusted QE is angle of site and what portion is elevation + CAS.

Adj QE = (adj el + CAS) + angle of site

The vertical interval and site to the registration point can be computed using the angle of site and the range corresponding to the adjusted time.

c. The procedure is based on the principle that fuze setting is a function of elevation plus complementary angle of site. After the registration is completed, the height of burst is raised vertically by an amount sufficient to enable the burst to be seen by an aiming circle located near base piece. The burst is raised by increasing quadrant. The adjusted time is fired. The executive officer measures the angle of site to the burst. By subtracting the angle of site from the quadrant fired, elevation + CAS is determined. Because the fuze setting was not changed (i.e., the adjusted time was fired) the elevation + CAS determined is the true elevation + CAS. This



value is then subtracted from the adjusted QE, yielding a true angle of site and site is then computed.

d. The procedure for conducting an executive's high burst is outlined below:

(1) After the time registration, the FDC estimates the increase in site necessary to cause the bursts to be visible from the battery position and adds it to the adjusted quadrant from the registration. This site increase is based on the executive officer's reported site to crest. The FDC alerts the executive officer and then has base piece fire three rounds at the adjusted deflection, time, and increased quadrant. The executive officer measures the angle of site to each burst with an aiming circle, which is set up in the vicinity of base piece (within 30 meters). He then reports the average observed angle of site.

(2) At the fire direction center, the site to the registration point, the adjusted elevation, and the vertical interval between the battery and the registration point are computed (fig 15-4). The following procedure is used.

(a) The elevation plus CAS for the executive's high burst is determined by subtracting the average measured angle of site reported by the executive officer from the QE fired.

(b) The elevation plus CAS determined is the true elevation plus CAS to the registration point.

(c) The angle of site to the registration point is computed by subtracting the true elevation plus CAS from the adjusted QE to the registration point.

(d) The vertical interval between the battery and registration point is determined by multiplying the angle of site by the range to the registration point (corresponding to the adjusted time) using the C and D scales of the GST (the hairline will be over the vertical interval).

(e) Site to the registration point is computed by dividing the vertical interval (determined as in (d) above) by the range to the registration point with the GST using the appropriate charge and site range scale.

(f) The adjusted elevation is the adjusted QE minus the site.

*Example:*

A 155-mm howitzer M109A1 was registered on a point with charge 4GB. The adjusted data for the registration point included the adjusted time, 17.5, and the adjusted QE, 295 mils. The report from the executive officer following the executive officer's high burst was **OBSERVED AVERAGE**

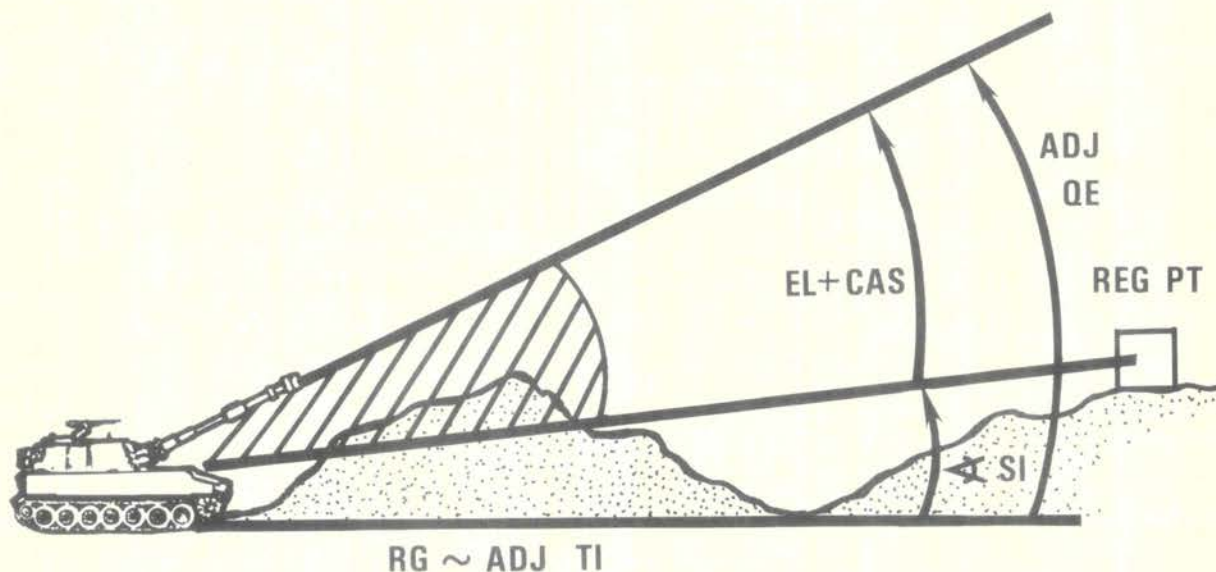


Figure 15-4. Comparison between adjusted QE and EL plus CAS.

**ANGLE OF SITE PLUS 30.** The increased QE fired was 315. Determination of site to the registration point, adjusted elevation, and vertical interval is as follows:

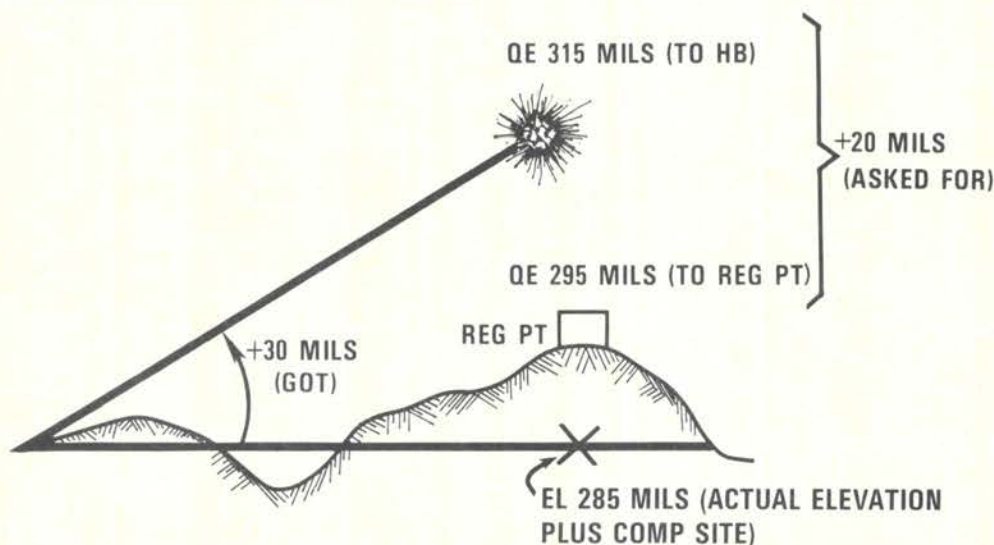
|                                                                                 |             |
|---------------------------------------------------------------------------------|-------------|
| Range corresponding to adjusted time (17.5)                                     | 4920 meters |
| QE fired for high burst                                                         | 315 mils    |
| Average angle of site to high burst                                             | +30 mils    |
| Elevation + CAS to high burst (QE fired (315) - average angle of site (+30))    | 285 mils    |
| Adjusted QE to registration point                                               | 295 mils    |
| Elevation + CAS to registration point (same as elevation + CAS to high burst)   | 285 mils    |
| Angle of site to registration point (adjusted QE (295) - elevation + CAS (285)) | +10 mils    |
| Vertical interval (+10 × 4920, C and D scales)                                  | +48 meters  |
| Site (+48/4920, chg 4, TAG, GST)                                                | +11 mils    |
| Adjusted elevation (295 - (+11))                                                | 284 mils    |

e. After understanding the theory on which the determination of site by firing is based, it may be easier to use the "got minus asked for" rule to determine the angle of site. Consider the example above. If the angle of site to the registration point had been 0 mils, the increase in the quadrant elevation to 315 (an increase of 20 mils "asked for") would have caused the bursts to occur at a measured angle of site plus 20 mils (see figure 15-5). Because the bursts occurred 30 mils "got" above the horizontal, the registration point must have been 10 mils (angle of site) above the horizontal. The formula is angle of site to registration point = "got minus asked for." This angle of site must then be converted to site, as illustrated above.

#### 15-8. Time Plot, Site Known

Once an executive's high burst has been conducted and a site has been obtained, the technique known as time plot, site known is used to determine range and altitude. The following procedures are accomplished.

- Derive the adjusted elevation by subtracting the known site from the adjusted QE.
- Determine the range from the battery



$$\text{GOT} - \text{ASKED FOR} = +30 - (+20) = +10 \text{ MILS ANGLE OF SITE}$$

Figure 15-5. "Got minus asked for" diagram.



to the registration point corresponding to the adjusted time.

c. Use the known site to determine the battery altitude by converting it to a vertical interval and applying it to the assumed altitude of the registration point.

#### Time Plot, Site Known

Adjusted elevation = adj QE - site

Polar plot range = range ~ adjusted time

VI = site  $\times$  polar plot range

Battery altitude = registration point altitude - VI

#### Example:

Continuing the previous example, the following data is known.

|                             |               |
|-----------------------------|---------------|
| Adj Ti                      | 17.5          |
| Adj QE                      | 295 mils      |
| Site                        | +11 mils      |
| Assumed reg pt alt          | 400 meters    |
| (1) True adjusted elevation |               |
| Adj QE (295) - site (+11)   | = 284 mils    |
| (2) Polar plot range        |               |
| Rg ~ adj ti (17.5)          | = 4920 meters |

|                                             |              |
|---------------------------------------------|--------------|
| (3) Vertical interval                       |              |
| Site (+11) $\times$ polar plot range (4920) | = +48 meters |
| (4) Battery altitude                        |              |
| Reg pt alt (400) - VI (+43)                 | = 352 meters |

#### 15-9. Deflection Index

After the battery has been polar plotted on the chart, the deflection index is constructed using the adjusted deflection (see figure 15-6).

#### 15-10. GFT Settings

The GFT setting for a battery using an observed firing chart is made in the normal manner.

a. Place the manufacturer's hairline over the range from the battery to the registration point.

b. Place a dot on the adjusted elevation. Draw the elevation gageline through the adjusted elevation parallel to the Rg/K line, as normal.

c. Place a dot on the adjusted time. Draw the time gageline through the adjusted time parallel to the Fz/K line, as normal.

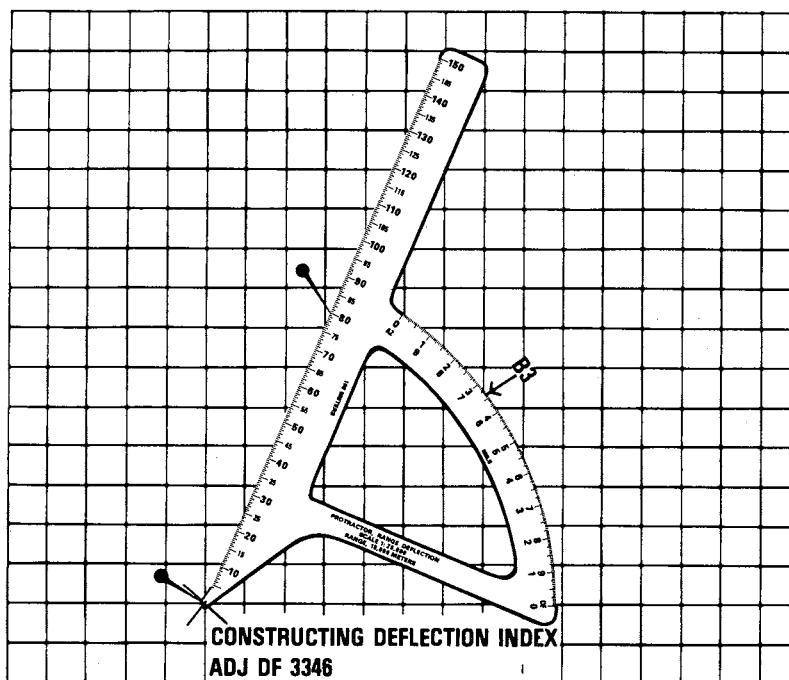


Figure 15-6. Construction of an OF chart deflection index.

## Section III. BATTALION OBSERVED FIRING CHARTS

### 15-11. Introduction

a. The basic concept behind battalion observed firing charts is:

Any two points that can be located by reference to a third point can be located by reference to each other.

b. For example, using the techniques previously described, the batteries are located with respect to the registration point (fig 15-7). After the batteries are plotted on the firing chart from the registration point, the firing chart accurately portrays the relationship between the locations of the batteries graphically.

c. This accurate portrayal of the relationship among the battery locations allows for the accurate massing of fires within the battalion on any target located by adjustment of one of the batteries or by a shift from a known point (known to all three batteries).

d. The techniques used in the construction of a battalion observed firing chart are the

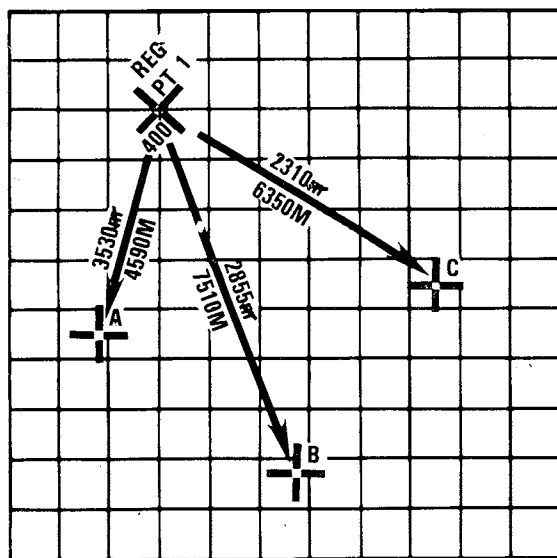


Figure 15-7. Location of batteries with respect to registration point.

same as those used for the construction of a battery observed firing chart.

### 15-12. Determination of Direction for Polar Plotting

The direction used for polar plotting each battery is determined using the same procedures described in paragraph 15-3.

### 15-13. Percussion Plot, VI Estimated

a. Range and altitude may be determined for each battery using the procedure presented in paragraphs 15-4 and 15-5.

b. If the relative altitude of the batteries can be estimated, the accuracy of the firing chart can be improved. One battery is selected as a reference battery and is assigned the same altitude as the registration point. The vertical intervals of the other batteries are estimated and compared with the altitude of the reference battery to obtain their altitudes. The procedure outlined in paragraph 15-5 is then followed.

#### Example:

(1) *Estimated vertical intervals.* Firing is conducted with 155-mm howitzer, M109A1, charge 4GB, fuze quick, vertical intervals estimated; assumed altitude of registration point is 400 meters; Battery B is the reference battery. Estimated vertical intervals for the other batteries with reference to Battery B (reference battery) are as follows:

Battery A -42 meters

Battery C +34 meters

(2) *Adjusted data from registration.*

| Battery | Azimuth of Orienting |      |
|---------|----------------------|------|
|         | Adjusted QE          | Line |
| A       | 330                  | 1440 |
| B       | 323                  | 1718 |
| C       | 320                  | 1611 |

| Measured<br>Orienting<br>Angle | Adjusted<br>Deflection |
|--------------------------------|------------------------|
| 1820                           | 3241                   |
| 1913                           | 3214                   |
| 1592                           | 3179                   |

Direction of fire is generally north.

(3) *Determination of plot azimuths.*

(a) Back azimuth for Battery A. Determine the direction of fire by subtracting the orienting angle from the azimuth of the orienting line, adding 6400 mils to the azimuth of the orienting line, if necessary.

|                               |               |
|-------------------------------|---------------|
| Azimuth of the orienting line | = 1440        |
| Add 6400 mils                 | <u>+ 6400</u> |
|                               | 7840          |

|                                           |               |
|-------------------------------------------|---------------|
| Subtract the value of the orienting angle | <u>- 1820</u> |
| Azimuth of fire                           | = 6020        |

|                                                                            |               |
|----------------------------------------------------------------------------|---------------|
| To determine the back azimuth, subtract 3200 mils from the azimuth of fire | <u>- 3200</u> |
| Back azimuth                                                               | = 2820        |

(b) Back azimuth for Battery B.

Use the procedure outlined in (a) above.

|                           |               |
|---------------------------|---------------|
| Azimuth of orienting line | = 1718        |
| Add 6400 mils             | <u>+ 6400</u> |
|                           | 8118          |

|                                           |               |
|-------------------------------------------|---------------|
| Subtract the value of the orienting angle | <u>- 1913</u> |
| Azimuth of fire                           | = 6205        |

|                                                                            |               |
|----------------------------------------------------------------------------|---------------|
| To determine the back azimuth, subtract 3200 mils from the azimuth of fire | <u>- 3200</u> |
| Back azimuth                                                               | 3005          |

(c) Back azimuth for Battery C.

Use the procedure outlined in (a) above.

|                                           |               |
|-------------------------------------------|---------------|
| Azimuth of orienting line                 | = 1611        |
| Subtract the value of the orienting angle | <u>- 1592</u> |
| Azimuth of fire                           | = 19          |

*Note.* It was not necessary to add 6400 mils to the azimuth of the orienting line because the orienting angle could be subtracted without this step.

|                                                                     |             |
|---------------------------------------------------------------------|-------------|
| To determine the back azimuth, add 3200 mils to the azimuth of fire | <u>3200</u> |
| Back azimuth                                                        | = +3219     |

(4) *Determination of plot ranges.*

(a) Determination of plot range for Battery B. When Battery B is used as the reference battery, the altitude is the same as the registration point; therefore, the site is zero.

Determine the range corresponding to the adjusted QE.

|                               |        |
|-------------------------------|--------|
| Range corresponding to QE 323 | = 5370 |
|-------------------------------|--------|

(b) Determination of plot range for Battery A. Compute the altitude of the battery, by applying the estimated vertical interval to the reference battery.

|                     |              |
|---------------------|--------------|
| Altitude (400 - 42) | = 358 meters |
|---------------------|--------------|

Compute the vertical interval between the battery and the registration point for the computation of site.

|                                  |              |
|----------------------------------|--------------|
| Vertical interval (400 - (+358)) | = +42 meters |
|----------------------------------|--------------|

Determine the initial range corresponding to the adjusted QE for use in the initial computation of site.

|                               |        |
|-------------------------------|--------|
| Range corresponding to QE 330 | = 5460 |
|-------------------------------|--------|

Compute the first apparent site.

|                                                |      |
|------------------------------------------------|------|
| First apparent site (+42 ÷ 5460, chg 4GB, TAG) | = +9 |
|------------------------------------------------|------|

Using the initial site,  
compute the first  
apparent elevation.

First apparent  
elevation

$$(QE\ 330 - (+9)) = 321$$

Determine the range  
corresponding to  
elevation 321.

$$= 5340$$

Using the same  
vertical interval and  
the new range,  
compute a new site.

$$\text{Site } (+42 \div 5340, \text{ chg } 4GB, \text{ TAG}) = +9$$

*Note.* If the site is within 1 mil of the site previously computed, it is used to determine the adjusted elevation, which, in turn, is used to determine the plot range.

Determine the  
adjusted elevation.

$$\text{Adjusted elevation} \\ (QE\ 330 - (+9)) + 321$$

Plot range corresponds  
to the adjusted  
elevation.

$$\text{Plot range at} \\ \text{elevation 321} = 5340$$

(c) Determination of plot range for Battery C. Compute the altitude of the battery by applying the estimated vertical interval to the reference battery.

$$\text{Altitude } (400 + 34) = 434 \text{ meters}$$

Compute the vertical interval between the battery and the registration point, for the

computation of site.

Vertical interval

$$(400 - (+434)) = -34 \text{ meters}$$

Determine the initial range corresponding to the adjusted QE for use in the initial computation of site.

Range corresponding to

$$QE\ 320 = 5330$$

Compute the first  
apparent site.

$$\text{First apparent site} \\ (-34 \div 5330, \text{ chg } 4GB, \\ \text{target below gun} \\ \text{(TBG)}) = -7$$

Using the initial site,

Compute the first  
apparent elevation.

$$\text{First apparent eleva-} \\ \text{tion } (QE\ 320 - (-7)) = 327$$

$$\text{Range} \\ \text{corresponding to} \\ \text{elevation 327} = 5420$$

Using the same vertical  
interval and the new  
range, compute a new  
site.

$$\text{Site } (-34 \div 5420, \\ \text{chg } 4GB, \text{ TBG}) = -7$$

This site agrees with the last site computed; therefore, the adjusted elevation is 327.

Plot range corresponding to adjusted elevation 327 = 5420

(5) Plot data for batteries in reference to the registration point.

| Battery | Back azimuth | Deflection index | Vertical interval | Altitude battery | Adjusted QE | Site | Adjusted elevation | Plot range |
|---------|--------------|------------------|-------------------|------------------|-------------|------|--------------------|------------|
| A       | 2820         | 3241             | +42               | 358              | 330         | +9   | 321                | 5340       |
| B       | 3005         | 3214             | 0                 | 400              | 323         | 0    | 323                | 5370       |
| C       | 3219         | 3179             | -34               | 434              | 320         | -7   | 327                | 5420       |

## 15-14. Time Plot

a. The range and altitude for each battery may be computed using the procedure described in paragraph 15-6.

b. If the site for one battery can be determined (executive's high burst), a graphical firing table setting can be constructed and used to determine sites for the other batteries of the same caliber.

(1) Determine the adjusted elevation for the battery, the site of which is known, by subtracting the known site from the adjusted quadrant elevation and determine the GFT setting. The range to be used in the GFT setting is the range corresponding to the adjusted time; an elevation gageline and a time gageline are constructed.

(2) If the site for only one battery is known, the adjusted data of that battery is used to establish a common GFT setting for all batteries, using the procedures in (1) above.

*Example:*

Batteries A, B, and C of a 155-mm M109A1 howitzer battalion have registered on registration point 1 with fuze quick and time, lot XY, charge 4GB, and have reported the following adjusted data:

| Battery | Adjusted Time | Adjusted Quadrant Elevation |
|---------|---------------|-----------------------------|
| A       | 20.5          | 360                         |
| B       | 19.8          | 343                         |
| C       | 19.2          | 347                         |

Altitude of registration point 1 is 400 meters. Battery B conducted an executive's high burst to determine site as indicated below.

1. B battery FDC commands to the base piece included the adjusted deflection, the adjusted time, and the quadrant elevation of 370 mils (asked for = +27 mils (370 - 343)).

2. Firing was conducted and the executive officer determined a mean angle of site to the high burst of +19 mils.

3. The site is determined at the FDC for use in the construction of the common GFT settings.

Mean angle of site to

high burst (got) = +19mils

Asked for (370 - 343) = +27mils

Angle of site (+19 - (+27)) = -8

Site for Battery B

Range at adjusted time

19.8 = 5440meters

Vertical interval

(-8 × 5440 C and D scales) = -43meters

Site (-43/5440, charge

4 GB, TBG) = -9mils

Adjusted elevation

(adjusted QE (343)

- site (-9)) = 352

4. This site is used to construct a common GFT setting for all batteries.

GFT B: Chg 4, Lot XY, Rg 5440, El 352, Ti 19.8.

5. The GFT setting is constructed in the normal manner using the range corresponding to the adjusted time. The adjusted elevation is determined by subtracting site from the adjusted quadrant elevation. Elevation and time gagelines are constructed even though the time plot point will, and the elevation plot point may, fall on the hairline.

c. To determine the relative site for the other batteries of the same caliber, move the time gageline to the adjusted time for the battery concerned and, using the common GFT setting, read the elevation under the elevation gageline. Subtract this elevation from the adjusted QE; the remainder is the site for the battery concerned.

d. Solution to the plot data for all batteries follows.

(1) Determination of Battery A's plot data.

(a) Using the common GFT setting, place the time gageline on Battery A's adjusted time, 20.5, and read the plot range under the hairline.

Range corresponding to time 20.5 = 5600 meters.



(b) With the time gageline still over time 20.5, read the elevation under the elevation gageline.

Elevation under gageline = 366 mils

(c) Determine the site by subtracting the elevation from the adjusted QE.

QE 360 - 366 = -6 mils

(d) Compute the vertical interval by multiplying the derived site by the range corresponding to the adjusted time.

Vertical interval  $(-6 \times 5600, \text{chg } 4GB, \text{TBG}) = -29 \text{ meters}$

(e) Determine the altitude of the battery by changing the sign of the vertical interval and adding the value to the altitude of the registration point.

$400 + (+29) = 429 \text{ meters}$

(2) Determination of Battery C's plot data.

(a) Using the common GFT setting, place the time gageline on Battery C's adjusted time, 19.2, and read the plot range under the hairline.

Range corresponding to time 19.2 = 5310 meters.

(b) With the time gageline still over time 19.2, read the elevation under the elevation gageline.

Elevation under gageline = 341 mils

(c) Determine the site by subtracting the elevation from the adjusted QE.

QE 347 - 341 = +6 mils

(d) Compute the vertical interval by multiplying the derived site by the range corresponding to the adjusted time.

Vertical interval  $(+6 \times 5310, \text{TAG}) = +28 \text{ meters}$

(e) Determine the altitude of the battery by changing the sign of the vertical interval and adding the value to the altitude of the registration point.

$400 + (-28) = 372 \text{ meters}$

Plot data in reference  
to the registration point

| Battery | Range | Adjusted<br>QE | Adjusted<br>elevation |
|---------|-------|----------------|-----------------------|
| A       | 5600  | 360            | 366                   |
| B       | 5440  | 343            | 352                   |
| C       | 5310  | 347            | 341                   |

| Site | Vertical<br>interval | Altitude |
|------|----------------------|----------|
| -6   | -29                  | 429      |
| -9   | -43                  | 443      |
| +6   | +28                  | 372      |

e. If each battery conducts an executive's high burst to determine site, each battery will determine its own VI based on its respective angle of site. Each battery will determine a separate respective angle of site. Each battery will determine a separate GFT setting using the procedure discussed in paragraph 15-14b.

## Section IV. REPLOTTING TARGETS ON THE OBSERVED FIRING CHART

The considerations and procedures for replotting targets on an observed firing chart are the same as those for replotting targets on the surveyed firing chart except that the target coordinates will not be sent outside the battalion that has established its own arbitrary grid system.

### 15-15. Replot Deflection

a. The deflection fired during FFE or the

deflection determined from the refinement data may not reflect the true total deflection correction to the target. The replot deflection is computed in the following manner.

(1) Determine the drift correction corresponding to the first apparent elevation (fuze Q or VT) or the true elevation (fuze time).

(2) Algebraically subtract the drift from the final deflection fired/deflection computed

to the refinement data. This is the replot deflection.

b. For example, a battery has just finished a mission and has received the following refinement data:

LEFT 20, ADD 10, UP 10

|                                            |      |
|--------------------------------------------|------|
| Chart deflection to refined data           | 3276 |
| Elevation from chart range to refined data | 342  |
| Drift corresponding to elevation 342       | L7   |
| Replot deflection (3276 - L7)              | 3269 |

#### 15-16. Quick, VT, and Time Fuze Replot

Targets fired with point-detonating fuze are replotted on the observed firing chart in the same manner as on the survey firing chart with the following exceptions.

a. The target altitude is assumed to be the battery altitude in the absence of any other information. If the observer has given any indication of target altitude (up/down corrections), these are applied to the battery altitude to determine the target altitude and VI.

b. When relative altitudes are determined as in paragraph 15-13, the adjusted elevation is determined by successive approximation.

(1) The vertical interval between the battery in question and the target is computed by applying the difference in altitude between the battery in question and

the reference battery to the vertical interval between the reference battery and the target.

(2) Compute an apparent site for the battery in question by using the VI and the range corresponding to the final quadrant elevation for the battery.

(3) Derive an apparent adjusted elevation by subtracting the apparent site from the final quadrant elevation.

(4) Compute a new site by using the vertical interval and the range corresponding to the apparent adjusted elevation and determine a new adjusted elevation. If the new site varies by more than 1 mil from the apparent site, continue successive approximation until two successive sites agree or are within 1 mil.

(5) When the apparent site is within 1 mil of the last site computed, determine the adjusted elevation. The replot range is the range corresponding to the adjusted elevation.

c. Targets fired with fuze VT are replotted on the observed firing chart using the procedure described above. The HOB correction (20/R) must be stripped out of the final quadrant before determining vertical interval when M513 or M514 VT fuze is used. Target altitude used in the replot process is the battery altitude unless the observer has given an up/down correction. In this case the correction is applied to the battery altitude to determine the target altitude.

d. Targets fired with fuze time are replotted on the observed firing chart using the replot procedures described in chapter 10.

## Section V. OBSERVED FIRING CHART WITH INCOMPLETE SURVEY

#### 15-17. Description

A position area survey may be used in conjunction with an observed firing chart until a surveyed firing chart is available. Typical situations that might necessitate the

use of an observed firing chart based on the registration of one battery and a position area survey are:

a. When the lack of time or ammunition precludes registering all three batteries.

b. When the battalion displaces by echelon. Data can be prepared for the other batteries before they arrive at the new position.

c. When displacement of the battalion is to be made after dark. A single howitzer is brought up and registered during daylight. Data is ready for the entire battalion when it arrives.

d. When fire from positions is not permitted before a certain hour, but massing is required immediately after that time, a single registration from a registration position (alternate position) may be performed. Then data can be prepared for the nonregistering battery positions, which are tied to the registration position by means of the position area survey.

#### 15-18. Construction of an Observed Firing Chart with Position Area Survey

##### a. Determination of Locations.

(1) After the survey has been completed, the grid coordinates and altitudes of the nonregistering batteries are compared to those of the registering battery to determine the differences in easting, northing, and altitude. These values are recorded for future use in computing the new location of the batteries after the registering battery's raw grid coordinates have been determined based on the time plot observed firing chart procedure.

(2) One battery is registered on the registration point; from the adjusted data the observed firing chart is constructed by plotting the registering battery. Assumed grid coordinates and altitude are assigned to the registration point and the grid coordinates and altitude of the registering battery are located relative to the registration point.

(3) Using the grid coordinates and altitude from the registering battery, dE, dN, and dH are applied for each nonregistering battery to determine its coordinates and altitude relative to the registration point.

(4) The nonregistering batteries are plotted on the observed firing chart.

##### b. Constructing the Deflection Index.

(1) For the registering battery, the deflection index is constructed using the adjusted deflection (para 15-9).

(2) For the nonregistering batteries, the range-deflection protractor is oriented along the azimuth on which the battery was originally laid and the deflection index constructed at the referred deflection.

c. *GFT Settings.* A common GFT setting is used within the battalion. This GFT setting is determined by the registering battery. The nonregistering batteries can improve this GFT setting by applying the muzzle velocity variation between the registering battery and each nonregistering battery.

##### Example:

(1) The position area survey is begun using the following assumed data:

|                                       |            |
|---------------------------------------|------------|
| Assumed grid coordinates of Battery B | 2000040000 |
| Altitude (for survey purposes only)   | 400 meters |

(2) The commander has determined the general direction of fire for each battery and announced the following azimuths:

|           |           |
|-----------|-----------|
| Battery A | 6200 mils |
| Battery B | 6350 mils |
| Battery C | 150 mils  |

(3) The position area survey has been completed and the survey data is indicated below.

|                            |            |
|----------------------------|------------|
| Battery A                  |            |
| Grid coordinates           | 2101040382 |
| Altitude                   | 417 meters |
| Azimuth of orienting line  | 3710 mils  |
| Orienting angle            | 710 mils   |
| Battery B                  |            |
| Grid coordinates (assumed) | 2000040000 |
| Altitude                   | 400 meters |
| Azimuth of orienting line  | 918 mils   |
| Orienting angle            | 968 mils   |
| Battery C                  |            |
| Grid coordinates           | 1932139120 |
| Altitude                   | 378 meters |

Azimuth of orienting line 1321 mils

Orienting angle 1171 mils

(4) The dE, dN, and dH of the nonregistering batteries are computed and recorded for future application.

#### Battery A

Starting grid coordinates 2000040000

Battery A grid coordinates 2101040382

dE and dN +1010 +382

Starting altitude 400 meters

Battery A altitude 417 meters

dH +17 meters

#### Battery C

Starting grid coordinates 2000040000

Battery C grid coordinates 1932139120

dE and dN -679 -880

Starting altitude 400 meters

Battery C altitude 378 meters

dH -22 meters

(5) The adjusted data from the registration is listed below.

Charge 4GB

Lot XY

Adjusted deflection 3286 mils

Adjusted orienting angle

(measured after

registration) 1054 mils

Adjusted azimuth 6264 mils

Adjusted time 19.1

Site (executive's high

(burst)+7 mils

Adjusted QE 334 mils

Assumed grid coordinates

of registration point 1 4000060000

Assumed altitude 500 meters

#### (6) Plot data for registering battery.

(a) Back azimuth from registration point 1 to battery.

Adjusted azimuth  $6264 - 3200 = 3064$  mils.

(b) Plot range corresponding to adjusted time  $19.1 = 5290$  meters.

(c) Grid coordinates of battery using the plot data in (a) and (b) above = 4071054780.

(d) Altitude of battery.

Vertical interval  $(+7 \times \text{range } 5290, \text{TAG}) = +32$  meters.

Altitude of battery  $(500 - (+32)) = 468$  meters.

(e) Deflection index is constructed on the firing chart at the adjusted deflection, 3286 mils.

(7) GFT setting for the registering battery.

GFT B: Chg 4, Lot XY, Rg 5290, El 327, Ti 19.1.

(8) Plot data for nonregistering batteries.

(a) Plot data for battery A.

1. Determination of the plot grid coordinates for Battery A.

Final grid coordinates of

Battery B = 4071054780

dE and dN +1010 +382

Grid coordinates of

Battery A 4172055162

2. Determination of the altitude for Battery A.

Final altitude of

Battery B = 468 meters

dH = +17 meters

Altitude of Battery A 485 meters

3. Construction of the deflection index.

Azimuth 6200 Deflection 3200

(b) Plot data for Battery C.

1. Determination of the plot grid coordinates for Battery C.

Final grid coordinates of

Battery B 4071054780

dE and dN - 679 - 880

Grid coordinates of

Battery C 4003153900

2. Determination of altitude for Battery C.

Final altitude of

Battery B 468 meters

dH - 22 meters

Altitude of Battery C 446 meters

3. Construction of deflection index.

Azimuth 150 Deflection 3200

(9) GFT settings for nonregistering batteries.

Note. The GFT range for all batteries is the same.

(a) Battery A GFT setting (fig 15-8).

| TRANSFER OF GFT SETTING |                     |                             |                             |                          |                        |                                |                                |
|-------------------------|---------------------|-----------------------------|-----------------------------|--------------------------|------------------------|--------------------------------|--------------------------------|
|                         | ①                   | ②                           | ③                           | ④                        | ⑤                      | ⑥                              | ⑦                              |
| Btry                    | Bn BP<br>Comp<br>VE | MV Corr<br>Factor<br>D-22.4 | MV Rg<br>Corr<br>①x②=(5290) | Achieved<br>Rg<br>(5290) | Corr<br>Rg<br>③+④=5220 | El ~ ⑤<br>Use EL<br>(Gageline) | Ti ~ ⑦<br>Use Ti<br>(Gageline) |
|                         | M/S                 | M                           | 10M                         | 10M                      | 10M                    | m                              | FS                             |
| A                       | +3.0                | -22.4                       | -70                         | 5290                     | 5220                   | 323                            | 18.8                           |
|                         |                     |                             |                             |                          |                        |                                |                                |
|                         |                     |                             |                             |                          |                        |                                |                                |

Figure 15-8. A Battery GFT transfer.

GFT setting from registration.

GFT B: Chg 4GB, Lot XY, Rg 5290, El 327, Ti 19.1.

Muzzle velocity variation:

Battery A +2.4 m/s

Battery B -0.6 m/s

Entry range from Battery B (5290 + 0) = 5290 ~ 5300 meters

(b) C Battery GFT setting (fig 15-9).

Muzzle velocity variation:

Battery B -0.6 m/s

Battery C -1.8 m/s

Entry range from battery B (5290 + 0) = 5290 ~ 5300 meters

d. *Aiming Circle Procedure.* If survey has not been completed prior to the occupation of position, the batteries will be laid by azimuth, using different aiming circles. This procedure will not place the battalion on a common

| TRANSFER OF GFT SETTING |                     |                             |                             |                          |                        |                                |                                |
|-------------------------|---------------------|-----------------------------|-----------------------------|--------------------------|------------------------|--------------------------------|--------------------------------|
|                         | ①                   | ②                           | ③                           | ④                        | ⑤                      | ⑥                              | ⑦                              |
| Btry                    | Bn BP<br>Comp<br>VE | MV Corr<br>Factor<br>D-29.0 | MV Rg<br>Corr<br>①x②=(5290) | Achieved<br>Rg<br>(5290) | Corr<br>Rg<br>③+④=5320 | El ~ ⑤<br>Use EL<br>(Gageline) | Ti ~ ⑦<br>Use Ti<br>(Gageline) |
|                         | M/S                 | M                           | 10M                         | 10M                      | 10M                    | m                              | FS                             |
| C                       | -1.2                | 29.0                        | +30                         | 5290                     | 5320                   | 329                            | 19.2                           |
|                         |                     |                             |                             |                          |                        |                                |                                |
|                         |                     |                             |                             |                          |                        |                                |                                |

Figure 15-9. C Battery GFT transfer.

direction because of the differences in the magnetic needles. The differences in the magnetic needles can be corrected by having all batteries measure the orienting angles and, using the measured orienting angles, compute the directions of fire. For the registering battery, this is done to compute the plot azimuth on the firing chart. For the nonregistering batteries, the orienting angles are measured to determine the actual directions in which they were laid in reference to a common direction for the battalion. Using the computed azimuths, the deflection indexes are constructed at the referred deflections after the batteries have been plotted in reference to the registering battery.

This procedure would only be used in the absence of any other method of obtaining a common direction.

## Section VI. RADAR FIRING CHARTS

Radar firing charts are another means of delivering indirect fires when surveyed firing charts are not available. Three techniques can be used in conjunction with a radar observed high burst registration in constructing a firing chart. These techniques are:

Observed firing chart improved by radar (time plot).

Radar chart, no maps or survey.

Radar chart, relative location of registering piece and radar determined.

### 15-19. Observed Firing Chart Improved by Radar

a. The time plot chart improved by radar

may be constructed as soon as the registration of all batteries and a radar observed high burst registration by one of the batteries have been completed. Construction of the observed firing chart must not be delayed to await the availability of radar.

b. The time plot observed firing chart improved by radar is the most accurate type of observed firing chart that can be constructed. It has the following advantages over a time plot observed firing chart:

(1) An accurate range and vertical interval can be obtained from the radar location to the high burst. From this an accurate site can be determined. Applying the GFT setting determined by the radar high

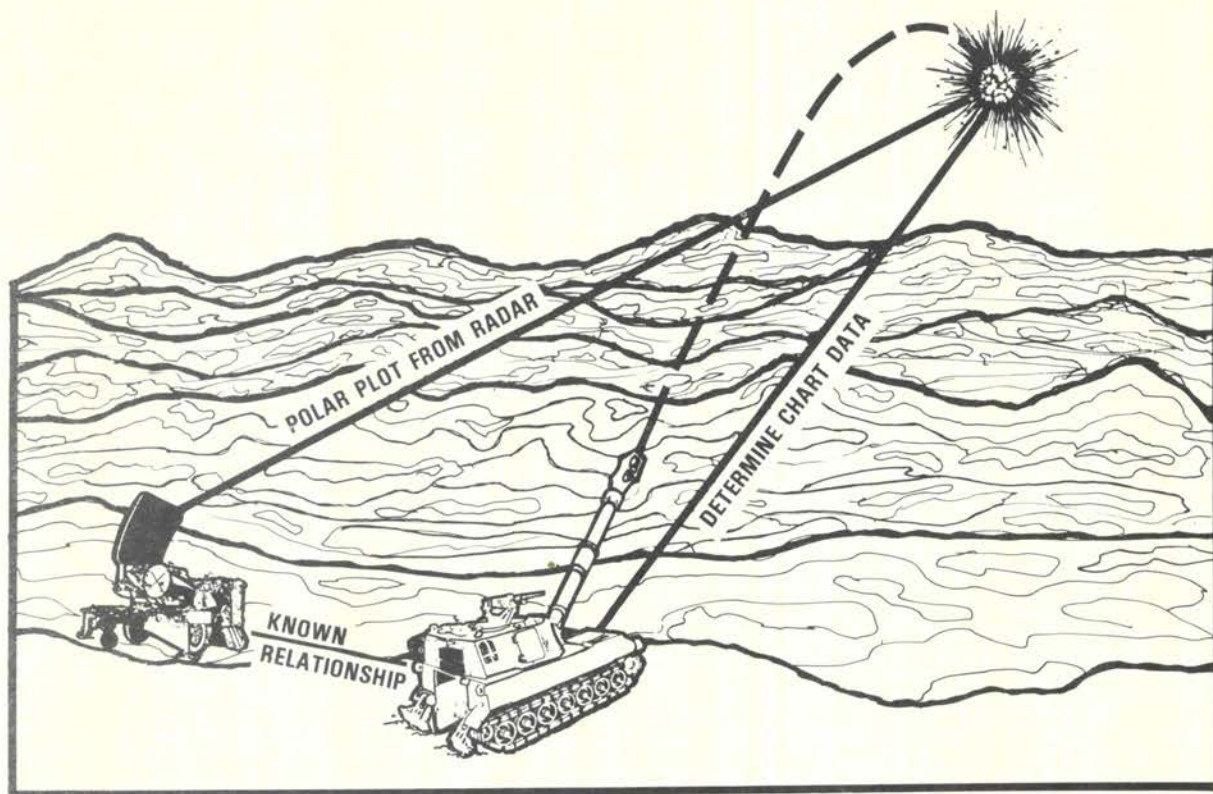


Figure 15-10. Radar high burst registration.

burst registration to the adjusted data will yield accurate polar plot data.

(2) A deflection correction can be determined based on the radar high burst registration. This deflection correction can then be applied to the adjusted deflections determined for each battery by its own registration. This will give a more accurate direction from the registration point to each battery improving the accuracy of the observed firing chart.

#### 15-20. Construction of a Radar Improved Chart

a. To construct a radar improved chart, register all batteries on a common point and determine adjusted data.

b. Determine the location of radar and one battery with respect to one another by survey. Plot the locations of the battery and radar on the firing chart.

c. The battery located with respect to the radar (by survey) fires a radar high burst registration (fig 15-10). The point selected for

the high burst registration should meet the following criteria:

(1) It should be located as close to the common registration point as possible.

(2) Site to the mean burst location should be less than 50 mils.

d. Plot the mean burst location on the firing chart.

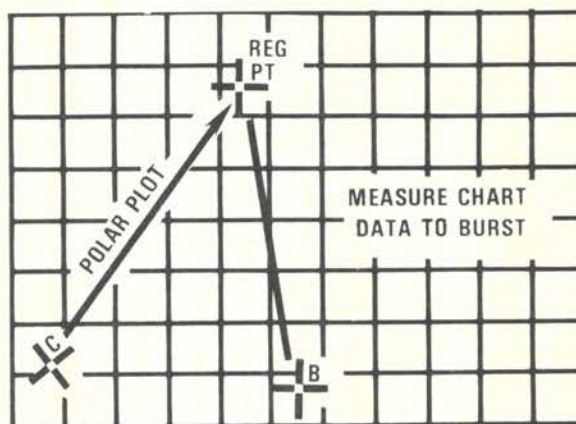


Figure 15-11. Determination of chart data to the mean burst location.



e. Determine chart data from the battery to the mean burst location (fig 15-11). This data consists of range, deflection, and site.

f. Determine the GFT setting. Chart range is achieved range. Adjusted elevation is the QE fired minus the site determined above. Adjusted time is the fuze setting fired in the radar high burst registration.

g. Compute the total deflection correction.

h. On another chart, plot the common registration point at an assumed grid and altitude; polar plot the batteries from the common registration point (fig 15-12).

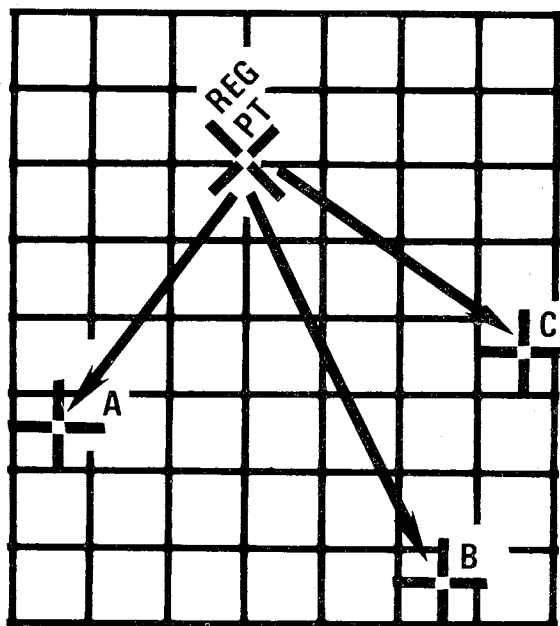


Figure 15-12. Common registration point.

#### Notes.

1. The azimuth of fire for each battery is determined in the manner described in paragraph 15-3. The azimuth of fire for each battery is then modified by the total deflection correction (*g* above).

If the total deflection is right (left), subtract (add) the total deflection correction from the adjusted azimuth. Then determine the back azimuth of that value and you have the polar plot azimuth for the registering battery.

2. Polar plot direction for each battery is the back azimuth of the corrected azimuth of fire.

3. Polar plot range is determined by the use of the GFT setting from the radar registration. The time gageline is placed on the adjusted time

to the common registration point and the range is read under the manufacturer's hairline.

i. Determine the VI and altitude to each battery. Place the time gageline over the adjusted time. Under the elevation gageline, read the adjusted elevation. Site is equal to the adjusted QE minus the derived adjusted elevation. Using the computed site, compute the respective VI and altitude for each battery.

j. Construct the deflection index using the chart deflection for each battery.

k. The GFT setting from the radar registration is used for all firing from radar improved charts.

#### Example:

All batteries of a 155-mm howitzer, M109A1, battalion have registered on a common point (assumed altitude 400) with charge 4GB, lot WZ.

#### Adjusted data from the registration:

| Btry | Adj az | Adj df | Adj QE | Adj ti |
|------|--------|--------|--------|--------|
| A    | 6046   | 3151   | 327    | 18.6   |
| B    | 6134   | 3166   | 314    | 18.1   |
| C    | 6229   | 3171   | 309    | 17.7   |

A survey is run between the radar and the base piece of Battery B. The radar is 6 meters above Battery B.

Battery B has fired a high burst registration over the registration point with charge 4GB, lot WZ, time 18.2, deflection 3166, quadrant 329.

The radar observes the registration and reports the grid coordinates and altitude of the mean burst location. This location is plotted on the chart and chart data is determined.

Chart data from Battery B to the mean burst location:

|            |      |
|------------|------|
| Deflection | 3181 |
| Range      | 5320 |

The GFT setting is determined.

|                                            |     |
|--------------------------------------------|-----|
| Altitude of high burst (reported by radar) | 473 |
| Altitude Battery B                         | 394 |

|                                                                                                                                                                                   |      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Altitude of radar (400 meters) - survey difference in radar and Battery B (6 meters)                                                                                              |      |
| Vertical interval Battery B to high burst                                                                                                                                         | +79  |
| Chart range: Battery B to high burst                                                                                                                                              | 5320 |
| Site: Battery B to high burst                                                                                                                                                     | +17  |
| (GST, Chg 4, TAG, +79/5320)                                                                                                                                                       |      |
| Adjusted elevation (329 - 17)                                                                                                                                                     | 312  |
| GFT B: Chg 4, lot WZ, rg 5320, el 312 ti 18.2.                                                                                                                                    |      |
| The total deflection correction is computed.                                                                                                                                      |      |
| Chart deflection Battery B to high burst                                                                                                                                          | 3181 |
| Adjusted deflection                                                                                                                                                               | 3166 |
| Total deflection correction                                                                                                                                                       | R15  |
| Polar plot data for all batteries is now computed using the adjusted data to the common registration point, the GFT setting (above), and the total deflection correction (above). |      |
| (1) Plot data for Battery A.                                                                                                                                                      |      |
| Adjusted azimuth to the registration point                                                                                                                                        | 6046 |
| Total deflection correction                                                                                                                                                       | R15  |
| Corrected azimuth to registration point (6046 - (R15))                                                                                                                            | 6031 |
| Polar plot azimuth (6031 - 3200)                                                                                                                                                  | 2831 |
| Polar plot range (from adjusted time 18.6)                                                                                                                                        | 5410 |
| Elevation                                                                                                                                                                         | 319  |
| Adjusted QE                                                                                                                                                                       | 327  |
| Site (adj QE - el)                                                                                                                                                                | +8   |
| Vertical interval (+8 × 5.410 chg 4GB, TAG)                                                                                                                                       | +37  |
| Altitude (400 - 37)                                                                                                                                                               | 363  |

|                                                                                           |      |
|-------------------------------------------------------------------------------------------|------|
| Deflection index constructed at chart deflection (adjusted df (3151) - tot df corr (R15)) | 3166 |
| (2) Plot data for Battery B.                                                              |      |
| Adjusted azimuth to the registration point                                                | 6134 |
| Total deflection correction                                                               | R15  |
| Corrected azimuth to the registration point (6134 - (R15))                                | 6119 |
| Polar plot azimuth (6119 - 3200)                                                          | 2919 |
| Polar plot range (from adjusted time 18.1)                                                | 5290 |
| Elevation                                                                                 | 310  |
| Adjusted QE                                                                               | 314  |
| Site (314 - 310)                                                                          | +4   |
| Vertical Interval (+4 × 5.290, chg 4GB, TAG)                                              | +18  |
| Altitude (400 - 18)                                                                       | 382  |
| Deflection index constructed at chart deflection (Adjusted DF (3166) - Tot df corr (R15)) | 3181 |
| (3) Plot data for Battery C.                                                              |      |
| Adjusted azimuth to the registration point                                                | 6229 |
| Total deflection correction                                                               | R15  |
| Corrected azimuth to the registration point (6229 - (R15))                                | 6214 |
| Polar plot azimuth (6214 - 3200)                                                          | 3014 |
| Polar plot range (from adjusted time 17.7)                                                | 5200 |
| Elevation                                                                                 | 303  |
| Adjusted QE                                                                               | 309  |
| Site (adj QE - el)                                                                        | +6   |
| Vertical interval (+6 × 5.200, chg 4GB, TAG)                                              | +27  |
| Altitude (400 - 27)                                                                       | 373  |
| Deflection index constructed at chart deflection                                          |      |



(Adj df (3171) - tot df  
corr (R15))

3186

### 15-21. Radar OF Charts

a. A battalion can occupy positions during darkness without maps or prior survey and be prepared to mass fires effectively. This is accomplished through the use of a type of observed firing chart called a radar chart. This chart is not as accurate as observed firing charts (time plot) improved by radar.

b. Accuracy of the radar chart can be improved by firing the three high burst registrations as close to the same point as possible.

c. The radar charts can be used in massing fires on targets reported by radar and on targets that have been adjusted on by one battery.

### 15-22. Construction of Radar OF Charts

a. Plot the radar location on the firing chart at assumed grid coordinates and an assumed altitude (fig 15-13).

b. One howitzer from each battery fires a radar observed high burst registration.

c. Radar will report the grid location and altitude (with respect to the radar assumed altitude) to each high burst registration.

d. Plot each high burst location on the chart from the radar.

e. Polar plot the location of each battery on the chart from its high burst location.

#### Notes.

1. Each high burst represents the location of the registration point for the battery that fired the high burst.
2. The battery is plotted from its high burst location along the back azimuth of the azimuth at which the high burst was fired.
3. The range from the high burst location at which the battery is plotted is the range corresponding to the fuze setting at which the high burst was fired.

f. Compute altitude for each battery.

#### Notes.

1. A vertical interval for each battery is

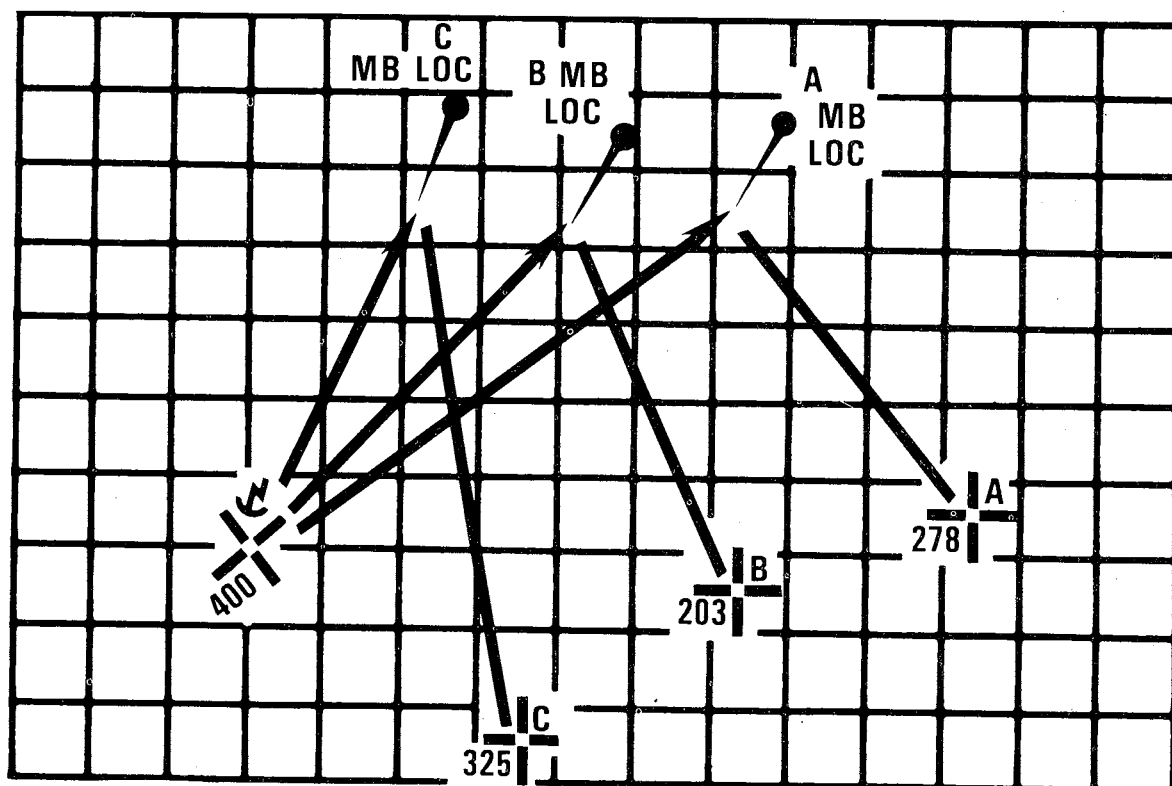


Figure 15-13. Radar, OF chart.

determined by multiplying the derived site and the range at which the battery is plotted on the GST.

2. The altitude of each battery is equal to the altitude of its high burst location minus its vertical interval.

g. Construct each battery's deflection index at the deflection fired in the high burst registration.

### 15-23. Radar Chart, Registering Piece Located

The accuracy of a radar chart can be improved substantially if the locations of the radar and only one registering piece in the battalion can be established with respect to each other. A GFT setting and total deflection correction can be determined in this situation. This will give improved plot data and therefore greater chart accuracy.

a. The relative locations of the radar and the registering piece can be established by survey or the registering piece may move to the radar position.

(1) Where one battery position is located in relation to radar after the construction of a radar chart without map or survey, a GFT setting and deflection correction can be derived from the earlier registration of that battery.

(2) When the registering piece is moved to the radar location, another high burst

registration must be fired to establish a GFT setting and a total deflection correction.

b. The GFT setting and total deflection correction are used in polar plotting each battery from its high burst location in the same manner as for an observed firing chart improved by radar (para 15-19).

c. Since the high burst locations are not a common point, this chart is not as accurate as the observed firing chart improved by radar.

### 15-24. FADAC

FADAC uses assumed data and procedures similar to the manual methods used to construct an OF chart to determine the relative location of the battery centers and the registration point. Initially, an assumed battery grid of (0,0) is used until registrations are complete, then a common grid is selected for the registration point and the relative battery grids are computed using the adjusted data and the FADAC polar plot function. The difference between the manual OF chart locations and the FADAC computed locations will be reflected in the ability of FADAC to use *known* nonstandard conditions such as met, powder temperature, muzzle velocity, projectile weight, etc., in determining the plot range and direction from the registration.

# APPENDIX A

## HOW TO TRAIN THE FDC

### Section I. THE FDC TRAINING PROCESS

#### A-1. Performance-Oriented Training

Success in the next battle will depend upon how well the training is conducted now. Performance-oriented training is training geared toward the performance of a particular job. FM 21-6, *How to Prepare and Conduct Military Training*, and TC 21-5-7, *Training Management in Battalions*, discuss performance-oriented training in detail. An understanding of these publications is essential to developing a good FDC training

program. The following terms are applicable to this appendix.

*a. The Training Objective.* The basis of performance-oriented training is the training objective. The training objective consists of three parts: a *task* to be performed, the *conditions* under which that task is to be performed, and the *standards* for the performance of that task (fig A-1).

*b. The Training Process.* The training process is a continuous, three-step process of evaluation, planning, and then training (fig A-2).

(1) *Evaluation.* Evaluation is the observation of performance under specified conditions to determine if the established standard is met. Evaluation may be conducted by observing training, or by more formal means such as skill qualification tests (SQT) or ARTEP evaluations.

(2) *Planning.* After completion of evaluation, planning must be conducted to decide how best to increase the proficiency in those tasks that were not performed satisfactorily. Planning includes establishing priorities among tasks identified to be taught and providing resources for training.

(3) *Training.* Training involves the organization and conduct of training. This step is tied back into evaluation to determine if the training has been adequate.

| TASK                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------|
| YOUR FDC MUST COMPUTE FIRING DATA FOR AN ADJUST FIRE, HIGH ANGLE MISSION USING FUZE QUICK.                                              |
| CONDITION                                                                                                                               |
| AN OBSERVER HAS JUST REQUESTED HIGH ANGLE FIRE ON A TARGET IN DEFILADE. SITE MUST BE INCLUDED.                                          |
| STANDARD                                                                                                                                |
| INITIAL ROUND DATA MUST BE COMPUTED WITHIN 45 SECONDS AFTER FDC RECEIVES THE COMPLETE CALL FOR FIRE; SUBSEQUENT DATA WITHIN 25 SECONDS. |

Figure A-1. The training objective.

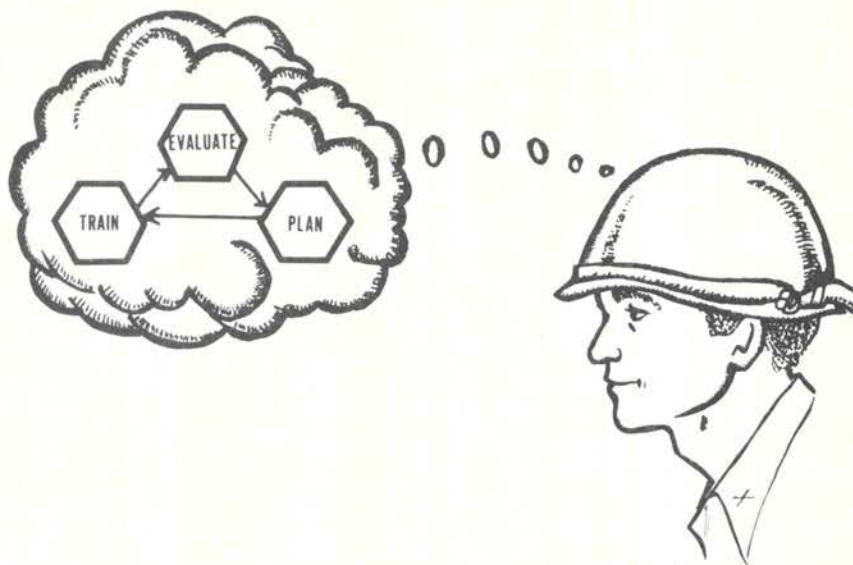


Figure A-2. The training process.

*c. The Training Manager.* The training manager is responsible for the planning, organization, conduct, and evaluation of training. In battalions the principal training manager is the battalion commander. The training manager provides guidance to the trainer. He analyzes the training objectives listed in the ARTEP, as well as his TOE-stated, implied, or contingency missions. Based on this analysis, the training objectives for the battalion are derived.

*d. The Trainer.* The trainer prepares, conducts, and evaluates training. He is responsible for accomplishing those objectives set forth by the commander. He analyzes the guidance received from the commander, develops simpler, intermediate objectives if necessary, evaluates the current status of training, and organizes and conducts the training necessary.

★ *e. Individual Training.* Individual training prepares individuals to perform the specific tasks related to an assigned MOS and duty position. The Soldier's Manual (SM) lists, by MOS, skill level, and duty position cluster, the critical combat tasks each soldier is expected to perform.

*f. Collective Training.* Collective training prepares soldiers to perform team or unit tasks essential to the accomplishment of a unit's mission. The ARTEP lists collective training objectives for the section, battery, and battalion.

#### ★ A-2. The Four-Step Approach (Fig A-3)

This appendix describes one way to approach FDC training. It is not the only way, but it is a process that has proven successful. The process is organized into a four-step approach: individual proficiency, team drill, team practice, and team proficiency. The process must be followed in order; each step builds upon the last step. The process of evaluation, planning, and training must occur at each step. This training process is designed for the performance-oriented approach to training.

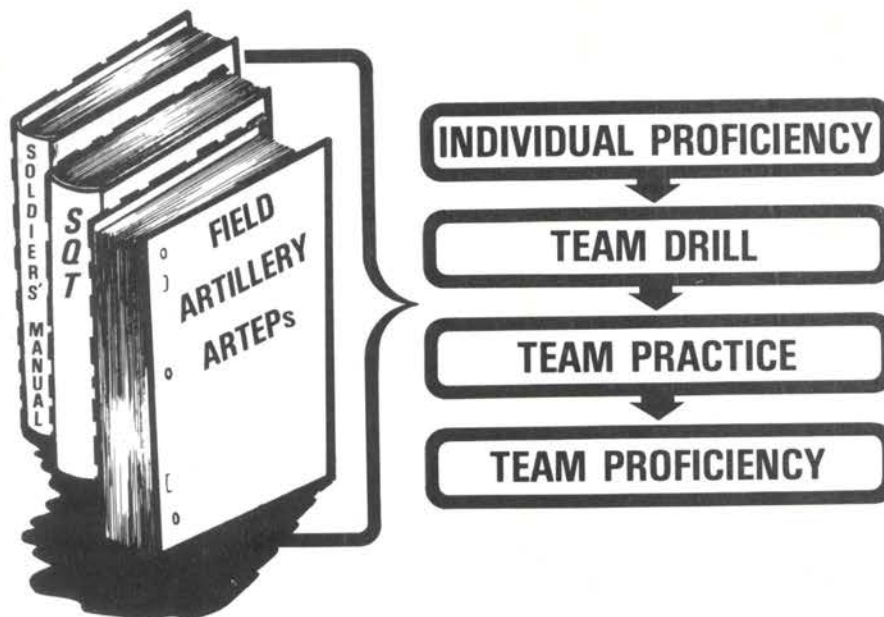
#### A-3. Individual Proficiency

*a. Description.* This step consists of insuring that all FDC personnel can perform those tasks listed in the appropriate Soldier's

Manual. Team training, field exercises, FTXs, etc., are not worthwhile if the individuals of the FDC team cannot perform their individual tasks. It follows that ARTEP delivery of fire tasks cannot be performed satisfactorily by a battalion if the individual FDC personnel cannot perform their individual tasks upon which the battalion tasks are based. This is always the first step in FDC training.

*b. Evaluation.* Each member of the FDC must be evaluated to determine if he can perform all required tasks satisfactorily. The best way to evaluate is to observe the soldier performing the task. The task, its conditions, and the expected standards should be extracted from the Soldier's Manual. SQT results or Job Book entries may also be used to determine the soldier's weak areas.

*c. Planning.* After each FDC member has been evaluated and his weak areas discovered, the training must be planned. Training should take place in a classroom-type atmosphere such as section rooms, classrooms, if available, or dayrooms. FADACs should be brought to the classroom area to facilitate collective training.



★ Figure A-3. The four-step approach to training.



Sufficient time should be scheduled to allow for teaching the task, practicing the task, and evaluating the performance of the task. Each soldier should bring the required equipment (GFTs, SMs, etc.), but the trainer should insure that training material is available. Films, TEC lessons, FM 6-40, FADAC User's Manual, Fire Direction Workbook chapters, and study guides should be used as appropriate. Priorities should be established to insure that critical tasks (those that the soldier must perform in battle) are taught first. Individual training programs for each individual should be planned to insure that their individual deficiencies are corrected.

*d. Training.* The training should be conducted by chief computers, FDOs, or FDC personnel who can already perform the particular task being taught. Using these FDC personnel as trainers or assistant trainers reduces boredom for them, motivates all personnel to perform better, and rewards those that have proven they can perform the task. Each class should address a particular Soldier's Manual task. The trainer should begin by discussing the task, conditions, and standards. This discussion should follow the Soldier's Manual. The "how to" of the task should then be reviewed. Each step discussed should be outlined in a reference that the soldier has: SM, FM 6-40, FADAC User's Manual, etc. Films or TEC lessons may be used. Authorized "shortcuts" and SOP procedures should be outlined. Practice problems should be completed, followed by a criterion test to serve as an evaluation.

#### **A-4. Team Drill**

*a. Description.* This step consists of insuring that the individual members of the FDC can work together in performing those tasks listed in the Section Training portion of the ARTEP. This step is only a walk-through of each task; time is not important. The objective of this step is to insure that the FDC can process a mission or perform any other task at a walk-through pace. Each individual must understand how he interacts with the other members before he can be expected to participate in a given section task under pressure. Communication within the section is stressed.

*b. Evaluation.* If a field exercise based on ARTEP tasks has been conducted recently, the results may indicate those section tasks that require additional training. Care must be taken in using this evaluation technique because an ARTEP task may have been unsatisfactory due to a failure of one individual (individual proficiency) instead of the failure of the team. An evaluation may take the form of having the section perform a section task from the ARTEP at a walk-through pace. Tasks evaluated should include those requiring independent action by the battery and battalion FDC and those tasks requiring battery and battalion FDC interaction such as battalion mass missions.

*c. Planning.* This training should be conducted in a classroom environment so that the communication and teamwork within the section can be emphasized. Again, sufficient time should be scheduled to allow for explanations, practice, and evaluation. The section equipment used in practice should be used in training, but communications with the FIST and firing battery should be simulated. Battery FDC to battalion FDC communications may be established between section rooms or classrooms using wire.

*d. Training.* The tasks, conditions, and standards should come from the Section Training portion of the ARTEP. The tasks may be simply described, or the "how to" may be shown with a film or demonstration. The interaction and communication between members or between battery and battalion FDC must be stressed. The goal should be to perform each task slowly but without error. Again, shortcuts and SOP procedures should be explained and outlined. How individual skills contribute to overall team performance should be pointed out so that each team member fully understands the importance of the part he plays within the section.

#### **A-5. Team Practice**

*a. Description.* In this step, the FDCs begin to practice what they have learned in steps one and two. The objective of this phase is to insure that the FDC can perform section, battery, and battalion delivery of fire tasks within ARTEP standards. This phase

consists of FDC CPXs and dry-firing exercises and can include integration of the firing battery and FIST.

*b. Evaluation.* ARTEP evaluations may be good indications of how much team practice is necessary. If individual proficiency and team drill have been accomplished, a dry field exercise or FDC CPX can be conducted to determine how well the system functions as a whole.

*c. Planning.* A training day of 6-8 hours should be set aside for team practice. The CPXs should be run in the gun park of the local training area using FDC trucks and communications equipment. The CPX can be integrated with firing battery and FIST training to make communications more realistic. The ARTEP (battery and battalion delivery of fire tasks) should form the basis of the FDC CPX.

*d. Training.* The objective of this training phase is to increase speed, building on what has previously been learned. The scenario should be flexible enough to allow instructional and administrative breaks and repetition of tasks requiring additional practice, yet structured enough to apply pressure to the FDC personnel. Proper communications with FIST, firing battery, and battery team members as well as trainers must be established. It is important in this phase that the entire FDC train together.

## A-6. Team Proficiency

*a. Description.* This step is the last step and involves the entire unit in a tactical situation. This is the phase right before and during an ARTEP evaluation. Actual ammunition (either full caliber or 14.5-mm) should be used and the entire unit should be involved. The objective of this phase is to insure that the FDC can perform its task in a tactical field environment.

*b. Evaluation.* An ARTEP evaluation should be conducted to evaluate the FDCs in this phase. The FDC evaluator must pay close attention to the FDC operations to pinpoint the actual causes for any unsatisfactory missions and any areas that require additional training.

*c. Planning.* This phase of training should be conducted at a major training area or 14.5-mm firing range in order to use actual ammunition. Enough time is needed to conduct some 24-hour operations, as in an extended field exercise. The scenario should be planned to simulate battlefield conditions.

*d. Training.* In addition to improving FDC operations, this phase is also used to improve other necessary tasks such as generator maintenance, setup of the FDC to include tents or tent extensions and security measures. Fully integrated FIST and FSO training should be included. Again, the ARTEP should be used to designate all tasks, conditions, and standards.

## Section II. HOW TO USE THE TRAINING PROCESS— A SCENARIO

The battalion FDO, CPT Jones, and the chief computer, SFC Wilson, are new to the unit and have been told that because of other commitments, there has been little FDC training in the past 3 months and that a major field exercise is scheduled in approximately 3 months. The battalion commander, as the training manager, has stated that the training

objectives listed in the ARTEP are the battalion's training objectives. CPT Jones found that there had been a large turnover in personnel since an ARTEP evaluation 4 months ago. Battery commanders state that the level of training of their FDCs is good, but SFC Wilson says that they have not been evaluated in 3 months and that their proficiency is really

unknown. CPT Jones and SFC Wilson decide to use the four-step process in evaluating, planning, and training the FDCs.

#### **A-7. Individual Proficiency**

*a. Evaluation.* CPT Jones decides to administer a mini-SQT to all FDC personnel to include battery FDOs in order to evaluate individual proficiency. SFC Wilson suggests that a test be developed for each particular job (VCO, HCO, RTO, computer, FDO). Because of time constraints, the priority is to insure that all VCOs can perform VCO-related tasks; HCOs, HCO-related tasks, etc; cross-training can occur later. CPT Jones agrees. Representative tasks from the SMs will be tested. CPT Jones and SFC Wilson must insure that all SM tasks that relate to ARTEP delivery of fire tasks are tested. Because of heavy duty commitments, all FDC personnel cannot be available on the same day; however, SFC Wilson works a schedule out with the first sergeants so that all VCOs will be available one day, all HCOs the next, etc. A 4-hour period is scheduled for each group. The evaluation is conducted and the results indicate weak areas for each individual.

*b. Planning.* Based on the results of the evaluation and the other commitments of the battalion (guard duty, parades, etc.), CPT Jones and SFC Wilson plan the individual proficiency training. They arrange for TEC lessons and films to be available during off-duty hours. Those soldiers that only require training in a few tasks will work on their own and act as assistant trainers during the day. Generally, the FADAC operators are poor, so SFC Wilson decides to bring all FADACs to the battalion classroom and conduct training there. Training

for the VCOs, RTOs, and computers is scheduled by groups—all VCOs together, all RTOs together, etc. Those tasks in which all soldiers of that job title need training will be taught first. Battery section rooms will be used, with each soldier responsible for bringing his own equipment. One battery FDO needs extra training so a schedule for his training is worked out with his battery commander. When soldiers complete all tasks satisfactorily, they will begin cross-training in another job.

*c. Training.* The training is to be conducted three times per week for 3 weeks, with FDOs and chief computers doing the training and proficient soldiers acting as assistants. All classes for a particular task include a demonstration of the task, individual practice, and evaluation. Special after-duty classes are organized for two particularly slow learners. An informal chart is maintained to outline the status of each individual. SFC Wilson also insures that all battery chief computers keep records in their Job Books.

#### **A-8. Team Drill**

*a. Evaluation.* Based on an evaluation of the amount of new personnel and the state of individual training, CPT Jones concludes that team drill needs to be conducted in all missions from simple adjust fire missions to nuclear missions.

*b. Planning.* The battery and battalion FDCs will train on their own using the section level tasks in the ARTEP. Training will occur in the section rooms or battalion classrooms. CPT Jones allotted 1 week for individual FDC team drill and 1 week for battalion/battery integrated team drill. FADACs are brought to the



section rooms and wire lines simulating the typical battalion communications system are installed.

*c. Training.* The training is conducted as scheduled. CPT Jones and SFC Wilson have the battalion S3 conduct an evaluation of the battalion's FDC operations at the close of the second week (during the battalion/battery team drill). Based on the S3's evaluation as well as his own, CPT Jones adds another 2 days to the training to further practice the battalion mass missions from the ARTEP.

*Note.* During the first two steps (individual proficiency and team drill) numerous problems arise because procedures within the battalion are not standardized or streamlined for efficiency. Illumination, mixed HE and WP, and smoke missions and battalion massing procedures are only a few examples. CPT Jones and SFC Wilson take this opportunity to develop a good, usable battalion fire direction SOP. (It is normal to develop and refine the SOP during these first two phases.)

#### **A-9. Team Practice**

*a. Evaluation.* The progress made during the team drill and subjective evaluation of the FDC's proficiency is the basis for the evaluation for this phase. Priorities are established to insure that the more difficult tasks are given the priority for training.

*b. Planning.* CPT Jones plans several CPXs of increasing complexity. The first three are scenario driven. To save time, CPT Jones decides to use the two CPXs written at Fort Sill for the advanced course gunnery students (FDO1FC and FDO1FD). Both are conducted in the gun park using the FDC trucks and TOE radios. Battery commanders and the S3 are used as FDC

evaluators. Each exercise is based on tasks from the ARTEP. CPT Jones has the scenarios modified for his specific needs. A third and fourth CPX are designed by CPT Jones and the other FDOs to concentrate on ARTEP tasks and weak areas discovered in the first two CPXs. The CPXs are more flexible and include FIST and firing battery participation and are conducted at local training areas where there will be a minimum of administrative interference.

*c. Training.* The four CPXs are conducted over a 2-week period. Evaluations of the first two CPXs are the basis for the contents of the third and fourth CPXs.

#### **A-10. Team Proficiency**

*a. Evaluation.* The evaluation in this phase consists of an ARTEP evaluation administered at the major training area (MTA). The results of the evaluation form the basis for post-evaluation training.

*b. Planning.* To insure that the maximum training value is derived from the training ammunition, CPT Jones has conducted training for this phase well ahead of time.

*c. Training.* Training during this phase consists of fine tuning FDC operations and making any small adjustments necessary for firing live ammunition. Most training will occur in the field with the entire battalion, but FDC exercises may take place in the gun park or local training areas. Training for 24-hour operations will receive additional emphasis.

#### **A-11. Post-Evaluation Training**

In reviewing the previous scenario, it can be seen that it took CPT Jones approximately 12 weeks to attain full team proficiency. Once the battalion has been brought to a high state of training, CPT Jones has several important tasks.

He must maintain as closely as possible the current level of training.

He must insure that all FDC personnel are cross-trained thoroughly.

He must develop a program to evaluate and train new personnel as quickly as possible.

*a. Maintaining Proficiency.* It would be ideal if a battalion could maintain peak performance standards throughout the year. This should be the goal of all units. Often, however, other commitments and higher priorities tend to displace FDC training on the list of priorities. The FDC trainer must be constantly aware of this. Realistically, CPT Jones knows that he cannot keep all FDCs at step four. He must, however, insure that the FDCs train at the team practice (step three) level wherever possible. Frequent CPXs and spot evaluations are essential. He must insure that the time required to regain peak proficiency is at a minimum. Training should be short-cycled: battery FDCs training in individual or section level tasks early in the

week and battalion/battery CPXs later in the week. In this manner, training occurs at several echelons within the training week. The training objectives continued in ARTEPs and Soldier's Manuals must be the guide to all training.

*b. Maintaining Cross-Training.* The commander and FDO have a responsibility to insure that all 13E soldiers are thoroughly trained in the 13E MOS. Individual training, team drill, and team practice must all incorporate cross-training of personnel. The Job Book or other informal devices are essential in keeping a record of the training of all personnel. With training time as valuable as it is, the battalion cannot afford to conduct "crash training" for an SQT.

*c. Training New Personnel.* New FDC personnel, whether officer, NCO, or enlisted, must be evaluated as soon as possible and trained up to the level of the rest of the FDC. It must be remembered that an individual must be proficient before he participates in team training.

## Section III. TRAINING AIDS

### A-12. Field Artillery School Support

*a.* The Field Artillery School has developed a considerable amount of training material for use by units in the field. The paragraphs that follow will reference these materials and explain how they can be ordered and used to support training.

*b.* One of the most worthwhile sources of instructional material for establishing a viable training program is the Field Artillery Catalog of Instructional Material. This catalog may be obtained by writing: Commandant, USAFAS, ATTN: ATSF-CR-TS, Fort Sill, OK 73503. Among the materials listed in the catalog are:

(1) *Class packets.* These materials may be used for individual, section, unit, and MOS-related training. A typical lesson contains three different packets:

(a) *Instructor's packet*—includes the lesson plan manuscript, one set of student materials, demonstration-size copies of forms used, and mailable training aids.

(b) *Slide packet*—includes the Vu-Graph transparencies referenced in the lesson plan manuscript.

(c) *Student packet* (materials for five students)—includes instructional notes and writs, workbook chapters, reference notes, practical exercises, and required training aids or devices.

(2) *Programed texts.*

(3) *Video tapes.*

(4) *All correspondence courses available through the Field Artillery School.*

### A-13. FDC Checklist

This checklist can be useful as an indicator of FDC proficiency. It is meant to serve only as an indication of team proficiency.

a. *Organization.*

1. Does the physical arrangement of the FDC allow the FDO to observe the work of all personnel with a minimum amount of movement?
2. Does the physical setup provide each individual ready access to the equipment, forms, and information necessary to the performance of his duties?
3. Is personal equipment (weapon, web gear, protective mask) readily available but stored so as not to interfere with FDC operations?
4. Is the FDC neat and orderly?
5. Are fire order and fire command standards readily visible to all personnel in the FDC?
6. Is the ammunition status readily available to the FDO?
7. Is the following information easily accessible?
  - a. Laying data
  - b. Piece distribution
  - c. MV information
  - d. Call signs
  - e. Residuals
  - f. GFT settings
  - g. Propellant temperature
  - h. Projectile weight
  - i. Terrain gun position corrections (TGPC)
8. Is the computer situated so that he can read data directly from the FADAC display panel (battery FDC primarily)?
9. Is there a situation map readily available and is it posted with the current tactical situation and fire support coordinating measures?
10. Are radio sets and telephones located to facilitate rapid, efficient communications and marked to identify nets/wire lines?
11. Is the current CEOI readily available?
12. Does the communications system allow all personnel in the FDC to hear the call for fire?
13. Has the communication system been verified as operational?

*b. General Operations.*

1. Are fire missions processed with minimum essential movement and communications?
2. Is the call for fire monitored and recorded by computer(s) and RTO?
3. Does the FDO quickly and fully analyze the mission upon receipt, to include a check of the situation map?
4. Does the FDO issue a clear fire order IAW posted standards?
5. Is the call for fire authenticated if necessary?
6. Is initial data determined by the fastest means for better response?

YES NO

[illegible]

YES NO

|    |     |
|----|-----|
| 1  | 2   |
| 3  | 4   |
| 5  | 6   |
| 7  | 8   |
| 9  | 10  |
| 11 | 12  |
| 13 | 14  |
| 15 | 16  |
| 17 | 18  |
| 19 | 20  |
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| 89 | 90  |
| 91 | 92  |
| 93 | 94  |
| 95 | 96  |
| 97 | 98  |
| 99 | 100 |

- 



- 

**Radiotelephone Operator (RTO)**

1. Does the RTO use proper communication procedures?
2. Are forms readily available upon which the RTO can record the call for fire?
3. Is the RTO (instead of the FDO) handling the bulk of radio calls?
4. Does the RTO know the net structures and call signs?
5. Does the RTO know challenge and authentication procedures?

YES NO

|  |  |
|--|--|
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

**Vertical Control Operator (VCO)**

1. Is the firing chart properly prepared, to include correct construction, labeling, and color-coding?
2. Is the chart neat and clean?
3. Does the VCO chart check with FADAC?
4. Is the VCO map color coded and marked for average site/altitude?
5. Are terrain gun position corrections (TGPC) sectors plotted on the chart?
6. Are all control measures required by the FDO plotted?
7. Are GFT settings applied to the GFT fan?
8. Is the chart prepared for 6400-mil operation if necessary?

YES NO

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**Horizontal Control Operator (HCO)/FADAC Operator**

1. Are program tests performed prior to initial operation?
2. Is there a FADAC log that reflects all stored data in an orderly and legible manner?
3. Does the operator announce charge for each set of initial FADAC firing data?
4. When the computer reads directly from the display panel, does the FADAC operator watch the panel to check data?
5. Are air filters cleaned periodically?
6. Does the FADAC have adequate ventilation?
7. Are FADAC generators alternated to permit periodic maintenance?
8. Is the FADAC properly grounded?

YES NO

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**Computer**

1. Are proper piece displacements plotted on the M 17 plotting board?
2. Is the current GFT setting applied to the GFT?

YES NO

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3. If applicable are terrain gun position corrections (TGPC) for all sectors computed and at the guns?
4. Are changes of data inputs rapidly sent from battery FDC to battalion FDC (e.g., muzzle velocity data, propellant temperature, projectile weight) and from battalion FDC to battery FDC (e.g., met data, transferred GFT setting, residuals)?
5. Are the guns alerted (computer at battalion FDC alert battery FDC) as soon as the first transmission of a call for fire is received?
6. Is data read directly from FADAC at the battery FDC?
7. Is each element of data recorded as it is sent to the guns?
8. Is END OF MISSION sent only when directed by the FDO?

YES NO

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*d. Training*

1. Does the FDO know what material is available from USAFAS and how to obtain it?
2. Do individual soldiers understand how to use the Soldier's Manuals (which tasks must be learned at each skill level and OJT)?
3. Are section personnel encouraged/required to make use of unit learning center assets, especially TEC programs?
4. Is cross-training of all FDC personnel an ongoing consideration?
5. Is there a system to provide for periodic evaluation of individual proficiency via written and performance tests?
6. Is training directed so as to meet or exceed standards listed in the appropriate ARTEP?
7. Are FDC personnel familiar with ARTEP section and overall mission standards?

YES NO

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**REMARKS:**

# APPENDIX B

## BALLISTICS

### B-1. Definition

Ballistics is the science that deals with the factors affecting the motion of projectiles. The subject is divided into three main areas (fig B-1): Interior ballistics that deals with the factors affecting the motion of the projectile before it leaves the muzzle of the piece, exterior ballistics that is concerned with the factors affecting the motion of the projectile from the time it leaves the muzzle of the weapon until it arrives at the point of impact, and terminal ballistics that is concerned with the projectile when it strikes the target or ground.

### B-2. Interior Ballistics

*a. Propellants and Projectile Movement.* The propellant and movement of the projectile within the tube will affect the velocity with which the projectile leaves the muzzle. This velocity is expressed in meters per second and is called muzzle velocity.

(1) A propellant is a low-order explosive that burns rather than detonates. When the gases generated by the burning propellant develop pressure sufficient to overcome initial bore resistance, the projectile begins to move.

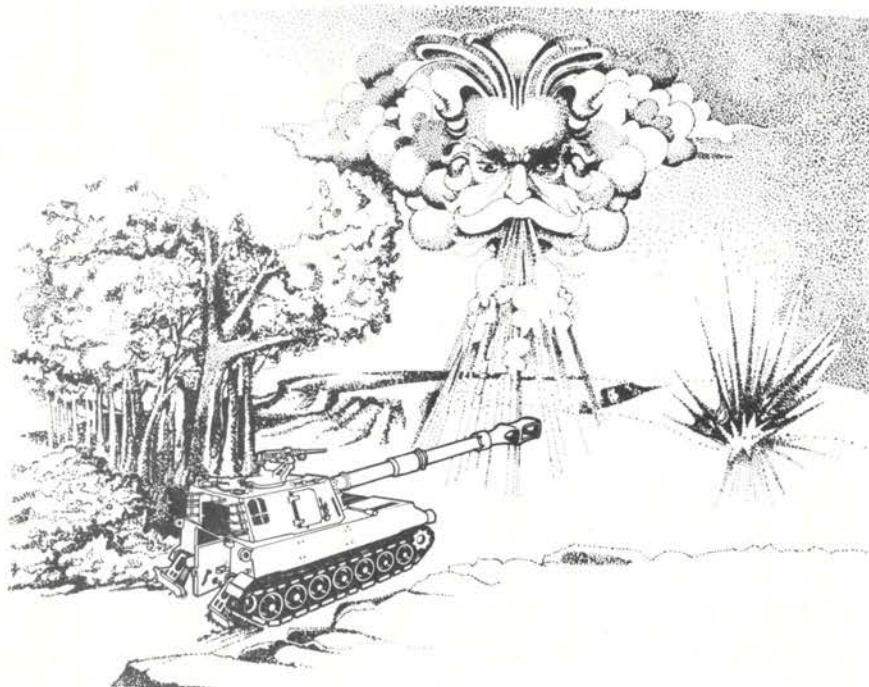


Figure B-1. Internal, external, and terminal ballistics.

(2) The gas pressure builds up quickly to a peak and gradually subsides shortly after the projectile begins to move. The peak pressure, together with the travel of the projectile in the bore, determines the speed at which the projectile leaves the tube. Some of the factors affecting the velocity performance of a weapon-ammunition combination are:

(a) An increase in rate of burning of a propellant increases gas pressure.

(b) An increase in the size of the powder chamber without a corresponding increase in the amount of propellant decreases gas pressure.

(c) Gas escaping around the projectile in the tube decreases pressure.

(d) An increase in bore resistance at any time has a dragging effect on the projectile and decreases velocity.

*b. Standard and Nonstandard Muzzle Velocity.* Applicable firing tables give the standard muzzle velocity for each charge. These standard values are based on an assumed standard weapon. In gunnery techniques, nonstandard velocity is expressed as a variation (plus or minus so many meters per second) from an accepted standard. The following discussion of factors causing nonstandard conditions treats each factor separately, assuming no influence from related factors.

(1) *Velocity trends.* Not all rounds of a series fired from the same weapon using the same ammunition lot will develop the same muzzle velocity. Under most conditions, the first few rounds follow a somewhat regular pattern rather than the random pattern associated with normal dispersion. This phenomenon is called velocity trends and the magnitude varies with the cannon, charge, and tube condition at the time each round is fired. Generally, the magnitude of velocity trends can be minimized when firing is started with a tube that is clean and completely free of oil.

(2) *Ammunition lots.* Each lot of ammunition has its own mean performance level when related to a common weapon.

(3) *Tolerances in new weapons.* All new cannons will not necessarily develop the

same muzzle velocity. In a new tube, the predominant factors affecting muzzle velocity are variations in the powder chamber and the interior dimensions of the bore.

(4) *Wear of tube.* Continued firing of a cannon wears away portions of the bore by the action of hot gases, chemical action, and movement of the projectile. These erosive actions are more pronounced when higher charges are fired. The greater the tube wear, the more muzzle velocity decreases. Normal wear can be minimized by careful selection of the charge and by proper cleaning of both the tube and the ammunition.

(5) *Nonuniform ramming.* Hard, uniform ramming is required for all rounds. Weak, nonuniform ramming causes a combined effect of escaping gases and a smaller propellant chamber that produces an increase in the dispersion pattern.

(6) *Rotating bands.* Rotating bands allow uniform pressure buildup and provide a minimum dragging effect on the projectile once motion has started. Dirt or burs on the rotating bands cause improper seating, which increases tube wear and contributes to velocity dispersion. If excessively worn, the lands may not sufficiently engage the rotating bands to impart the proper spin to the projectile. Insufficient spin reduces projectile stability in flight and can result in dangerously short, erratic rounds. When erratic rounds occur or excessive tube wear is noted, ordnance teams should be requested to determine the serviceability of each tube.

(7) *Propellant and projectile temperature.* Positive action must be taken to maintain uniform projectile and propellant temperatures; failure to do so results in erratic firing. The effect of an extreme change in projectile or propellant temperature can invalidate even the most recent registration corrections.

(8) *Moisture content of propellant.* Changes in the moisture content of propellant are caused by improper protection from the elements. These changes will affect muzzle velocity.



(9) *Position of propellant in the chamber.* In fixed and semifixed ammunition, the propellant has a relatively fixed position with respect to the chamber. In separate-loading ammunition, however, the position of the propellant depends on how the cannoneer inserts the charge. To insure proper ignition of the propellant, he must insert the charge so that the base of the propellant bag is flush against the obturator spindle.

(10) *Weight of projectile.* A heavier than standard projectile causes a decrease in velocity while a lighter than standard projectile causes an increase in velocity.

(11) *Coppering.* Coppering is the deposit of a thin film of copper on the bore (it occurs in the tube when the velocity is high enough to develop sufficient friction to remove the outer surface of the rotating band). The amounts of copper deposited vary with velocity. Excessive coppering causes erratic velocity performance by varying the resistance of the bore to projectile movement.

(12) *Propellant residues.* Residues from burned propellant and certain chemical agents mixed with the expanding gases are deposited on the bore surface. Proper care and cleaning will alleviate pitting and other damage to the tube.

(13) *Tube conditioning.* The temperature of the tube has a direct bearing on the developed muzzle velocity. A cold tube offers a different resistance to projectile movement than a warm tube does. A cold tube is less susceptible to coppering, even at high velocities. Additional factors are the weapon, the charge fired, oiliness of the tube, and the degree of coppering.

(14) *Determination of muzzle velocity.* The knowledge of past performance of a weapon-ammunition-charge combination must be relied on for the data needed and velocity performance must be predicted on this basis. The velocity level of each weapon must be determined at every opportunity.

c. *Summary.* Actual measurements of the muzzle velocity of a series of rounds, corrected for nonstandard conditions, depict the performance of a certain weapon-

ammunition-charge combination. The variation from standard can be obtained by comparison of the results of these measurements with the standard velocities listed in the firing table for the charge fired. Application of corrections to compensate for nonstandard muzzle velocity is one of the most important elements in the preparation of accurate firing data.

### B-3. Exterior Ballistics

Exterior ballistics deal with the factors affecting the motion of a projectile after it leaves the muzzle of a weapon; at that instant, the total effect of interior ballistics in terms of developed muzzle velocity and spin has been imparted to the projectile. Gravity causes the projectile to return to the surface of the Earth. If the projectile were fired in a vacuum, the path or trajectory would be simple to trace; however, when the projectile is fired in the atmosphere, the path becomes a complex curve. A given elevation and muzzle velocity can result in a wide variety of trajectories, depending on the combined properties of both the projectile and the atmosphere.

a. *The Trajectory.* The trajectory is the curve traced by the center of gravity of the projectile in its flight from the muzzle of the weapon to the point of impact or point of burst. The elements of the trajectory are classified into three groups: intrinsic, initial, and terminal.

(1) *Intrinsic elements* are those that are characteristic of a trajectory by definition. These elements are discussed in (a) through (g) below.

(a) *Origin.* The location of the center of gravity of the projectile when it leaves the muzzle of the piece is designated the origin of the trajectory. For the remaining definitions relating to the elements of the trajectory, the term "origin" will be used to designate the center of the muzzle when the piece has been laid.

(b) *Ascending branch.* That portion of the trajectory traced while the projectile is rising from the origin.

(c) *Descending branch.* That portion of the trajectory traced while the projectile is falling.

(d) *Summit.* The highest point of the trajectory.

(e) *Maximum ordinate.* The difference in altitude between the origin and the summit.

(f) *Level point.* The point on the descending branch that is the same altitude as the origin.

(g) *Base of trajectory.* The straight line from the origin to the level point.

(2) Initial elements are those that are characteristic at the origin of the trajectory. These elements are discussed in (a) through (j) below. (Refer to figure B-2.)

(a) *Line of elevation.* When the piece is laid, the line of elevation is the axis of the tube extended.

(b) *Line of departure.* A line tangent to the trajectory at the instant the projectile leaves the tube.

(c) *Jump.* The displacement of the line of departure from the line of elevation that exists at the instant the projectile leaves the tube.

(d) *Angle of site.* The smaller angle in the vertical plane from the base of the trajectory to the straight line joining the origin and the target. The angle of site compensates for the vertical interval.

(e) *Complementary angle of site.* An angle that is algebraically added to the angle of site to compensate for the nonrigidity of the trajectory.

(f) *Site.* The algebraic sum of the angle of site plus the complementary angle of site.

(g) *Complementary range.* The number of meters range correction equivalent to the number of mils complementary angle of site.

(h) *Line of site.* The straight line from the origin to a point, usually the target.

(i) *Angle of elevation.* The smaller angle at the origin in a vertical plane from the line of site to the line of elevation.

(j) *Quadrant elevation.* The smaller angle at the origin in a vertical plane from the base of the trajectory to the line of elevation. It is the algebraic sum of site plus the angle of elevation.

(3) Terminal elements are those that are characteristic at the point of impact. These

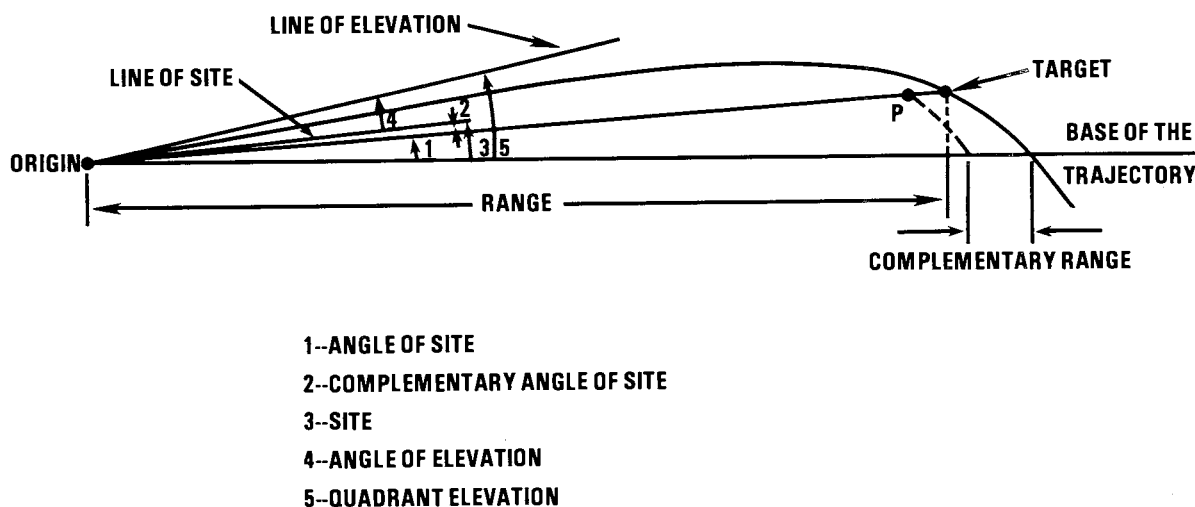


Figure B-2. Initial elements of the trajectory.

elements are discussed in (a) through (e) below. (Refer to figure B-3.)

(a) *Point of impact.* The point at which the projectile first strikes in the target area.

(b) *Line of fall.* A line tangent to the trajectory at the level point.

(c) *Angle of fall.* The vertical angle, at the level point, between the line of fall and the base of the trajectory.

(d) *Line of impact.* A line tangent to the trajectory at the point of impact.

(e) *Angle of impact.* The acute angle, at the point of impact, between the line of impact and a plane tangent to the surface at the point of impact.

*b. Characteristics of Trajectory in Standard Atmosphere.* The resistance of the air to a projectile depends on the air movement, density, and temperature. An air structure, called the standard atmosphere, is derived from assumed conditions of air density and air temperature and a condition of no wind. This standard atmosphere is used as a point of departure for computing firing tables. The most apparent difference between the trajectory in standard atmosphere and the trajectory in a vacuum is the reduction of

the range. This reduction occurs mainly because, in the atmosphere, the horizontal and vertical velocity components are not a constant, but are continually decreased by the retarding effect of the air. (Refer to figures B-4 and B-5.)

*c. Standard Conditions and Corrections.* Certain atmospheric, position, and materiel conditions are accepted as standard. These conditions are outlined generally in the introduction to firing tables. When variations from standard conditions are experienced, the trajectory will not conform to the predicted trajectory. Some of these variations can be measured and corrections can be applied to compensate for them. Among the conditions for which corrections may be determined are:

- (1) Vertical interval.
- (2) Propellant temperature.
- (3) Drift.
- (4) Ballistic wind.
- (5) Muzzle velocity.
- (6) Air temperature.
- (7) Air density.

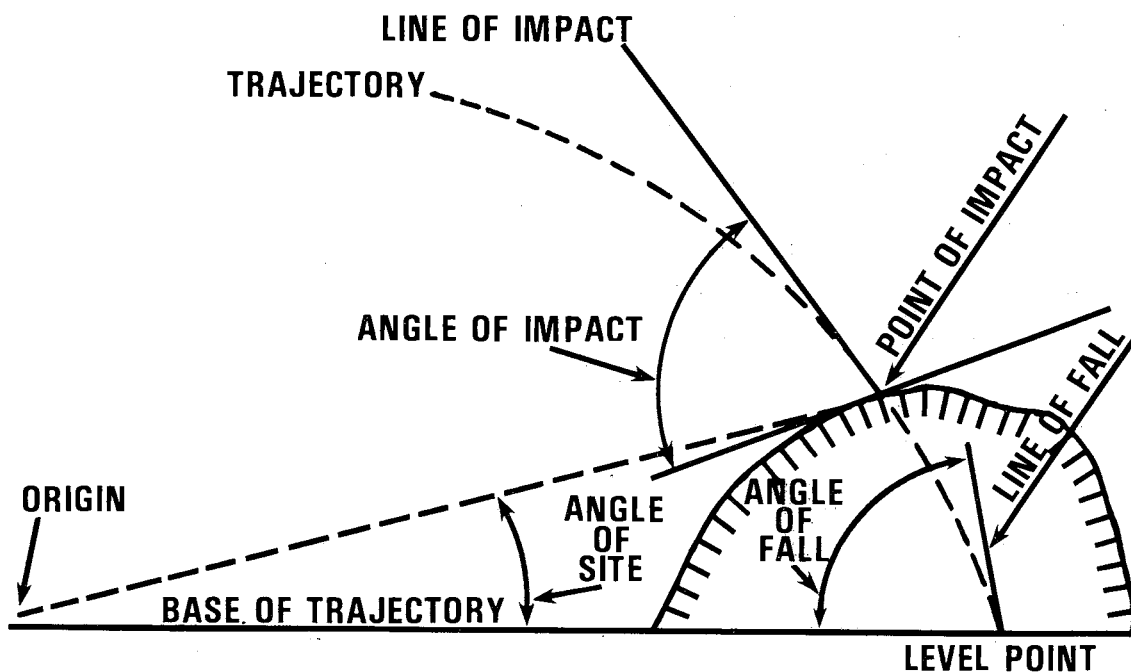
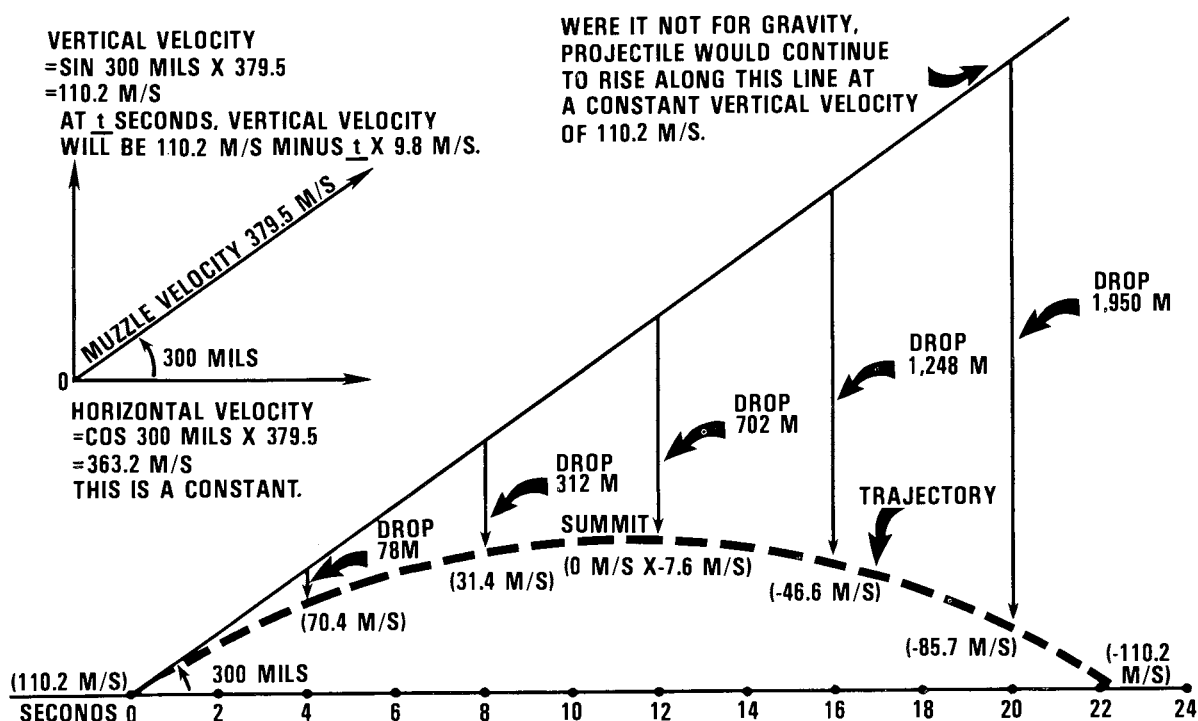


Figure B-3. Terminal elements of the trajectory.



HORIZONTAL VELOCITY IS A CONSTANT FROM ORIGIN TO LEVEL POINT; HENCE THE PROJECTILE WILL TRAVEL  $363.2$  METERS IN THE HORIZONTAL PLANE DURING EACH SECOND.

VERTICAL VELOCITY DECREASES FROM  $110.2 \text{ M/S}$  TO  $0 \text{ M/S}$  ON ASCENDING BRANCH AND INCREASES FROM  $0 \text{ M/S}$  TO  $110.2 \text{ M/S}$  ON DESCENDING BRANCH BOTH AT A RATE OF  $9.8 \text{ M/S}^2$ . VERTICAL VELOCITIES ARE SHOWN IN PARENTHESIS.

Figure B-4. Characteristics of trajectory in standard atmosphere—horizontal and vertical velocity.

- (8) Weight of projectile.
- (9) Rotation of the Earth.

#### d. Firing Tables.

(1) Firing tables are based on actual firings of the piece and its ammunition under, or correlated to, a set of conditions defined and accepted as standard. These standards are points of departure and corrections are used to compensate for variables in the weather-weapon-ammunition-charge combination that are known to exist at a given instant and location. The atmospheric standards accepted in US firing tables reflect the mean annual condition in the North Temperate Zone.

(2) The principal elements measured in experimental firings include angle of elevation, angle of departure, muzzle

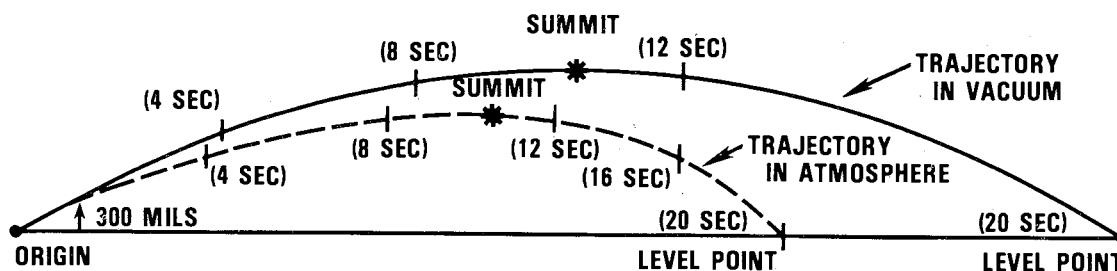
velocity, achieved range, drift, and concurrent atmospheric conditions.

(3) The main purpose of a firing table is to provide data required to bring effective fire on a target under any set of conditions. Data for firing tables is obtained from firings conducted with the weapon at various quadrant elevations. Computed trajectories, based on the equations of motion, are compared with the data obtained in the firings. The computed trajectories are then adjusted to the measured results and data is tabulated. Data for elevations not fired is determined by interpolation. Firing table data defines the performance of a projectile of known properties under conditions of standard muzzle velocity and weather and a motionless Earth. Firing tables list unit corrections as range correction for an

A TRAJECTORY IN STANDARD ATMOSPHERE, AS OPPOSED TO ONE IN A VACUUM, WILL BE AT A SHORTER RANGE AND AT A LOWER HEIGHT AFTER ANY SPECIFIC TIME OF FLIGHT.

THIS IS BECAUSE—

- (1) HORIZONTAL VELOCITY IS NO LONGER A CONSTANT BUT DECREASES WITH EACH SUCCEEDING TIME INTERVAL.
- (2) VERTICAL VELOCITY IS AFFECTED NOT ONLY BY GRAVITY BUT ALSO BY THE ADDITIONAL SLOWING DOWN FROM THE ATMOSPHERE.



NOTE:

- (1) THE SUMMIT IN A VACUUM IS MIDWAY BETWEEN THE ORIGIN AND THE LEVEL POINT; IN THE ATMOSPHERE, IT IS NEARER THE LEVEL POINT.
- (2) THE ANGLE OF FALL IN A VACUUM IS EQUAL TO THE ANGLE OF ELEVATION; IN THE ATMOSPHERE, IT IS GREATER.

Figure B-5. Trajectory in a standard atmosphere and in a vacuum.

increase (decrease) in each of the following factors: muzzle velocity, range, wind, air temperature, air density, and projectile weight. The appropriate unit correction for each listed range is given in meters. Each correction is computed on the assumption that all other conditions are standard. Actually, any given correction will differ slightly from that computed if one or more of the other conditions are nonstandard. The amount of difference depends on the effect of the other nonstandard conditions.

(4) The standard range is the range opposite a given elevation in the firing tables. It is assumed to be measured along the surface of a sphere concentric with the Earth and passing through the muzzle of a weapon. For practical purposes, standard range is the horizontal distance from the origin to the level point.

(a) The achieved range is the range that is developed as a result of firing with a certain elevation of the tube. If actual firing conditions duplicate the ballistic properties and meteorological conditions upon which the firing tables are based, the achieved range and the standard range are equal.

(b) The corrected range is the range that corresponds to the elevation that must be fired to reach the target.

(5) Deviations from standard conditions, if not corrected in computing firing data, will cause the projectile to impact or burst at a point other than the desired point. Corrections for nonstandard conditions are made to improve accuracy. Accuracy should not be confused with precision. Precision is related to tightness of the dispersion pattern without regard to its proximity to a desired

point. Accuracy is related to the location of the mean point of impact with respect to a desired point.

(a) *Range effects.* Some of the deviations from standard conditions affecting range are:

Vertical jump.  
Droop.  
Muzzle velocity.  
Projectile weight.  
Air resistance.  
Shell surface.  
The ballistic coefficient.  
Air temperature.  
Air density.  
Range wind.  
Rotation of the Earth.

(b) *Deflection effects.* Some of the deviations from standard conditions affecting deflection are:

Lateral jump.  
Drift.  
Crosswind.  
Rotation of the Earth.

#### B-4. Dispersion and Probability

a. *General.* If a number of rounds of the same caliber and same lot of ammunition are fired from the same settings in quadrant elevation and deflection, the rounds will not fall at a single point, but will be scattered in a pattern of bursts. In discussion of artillery fires, the natural phenomenon of chance is called dispersion. The array of bursts on the ground is the dispersion pattern. The points of impact of the projectiles will be scattered both laterally (deflection) and in depth (range). Dispersion is the result of minor variations of many elements from round to round and should not be confused with variations in point of impact caused by mistakes or constant errors. (Refer to figure B-6.)

b. *Mean Point of Impact (MPI).* For any large number of rounds fired, it is possible to draw a line perpendicular to the line of fire that will divide the points of impact into two equal groups, half over and half short, representing the mean range. It is also possible to draw a line parallel to the line of

|     | .02   | .07   | .16   | .25   | .25   | .16   | .07   | .02   |              |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|--------------|
| .02 | .0004 | .0014 | .0032 | .0050 | .0050 | .0032 | .0014 | .0004 |              |
| .07 | .0014 | .0049 | .0112 | .0175 | .0175 | .0112 | .0049 | .0014 |              |
| .16 | .0032 | .0112 | .0256 | .0400 | .0400 | .0256 | .0112 | .0032 |              |
| .25 | .0050 | .0175 | .0400 | .0625 | .0625 | .0400 | .0175 | .0050 |              |
| .25 | .0050 | .0175 | .0400 | .0625 | .0625 | .0400 | .0175 | .0050 | LINE OF FIRE |
| .16 | .0032 | .0112 | .0256 | .0400 | .0400 | .0256 | .0112 | .0032 |              |
| .07 | .0014 | .0049 | .0112 | .0175 | .0175 | .0112 | .0049 | .0014 |              |
| .02 | .0004 | .0014 | .0032 | .0050 | .0050 | .0032 | .0014 | .0004 |              |

Figure B-6. Dispersion graph.

fire with half of the rounds left and half to the right, representing the mean deflection. The intersection of the two lines is the mean point of impact.

c. *Probable error.* Probable error (fig B-7) is an error that is exceeded as often as it is not exceeded. As an example, consider the 50 percent of rounds that have fallen over the MPI. At some point over the MPI a second perpendicular line can be drawn splitting the overs into two equal parts. The distance from the MPI to the new perpendicular line is called one probable error. For any normal dispersion pattern, a distance of four probable errors on either side of the mean

point of impact will include virtually all the rounds in the pattern. In addition, what is true in range will also be true in deflection.

(1) Range probable error is shown in the firing tables and can be taken as an index of the precision of the piece.

(2) "Fork" is the term used to express the change in elevation in mils necessary to move the mean point of impact four range probable errors.

(3) Deflection probable error is given in the firing tables. For cannons, the deflection probable error is considerably smaller than the range probable error.

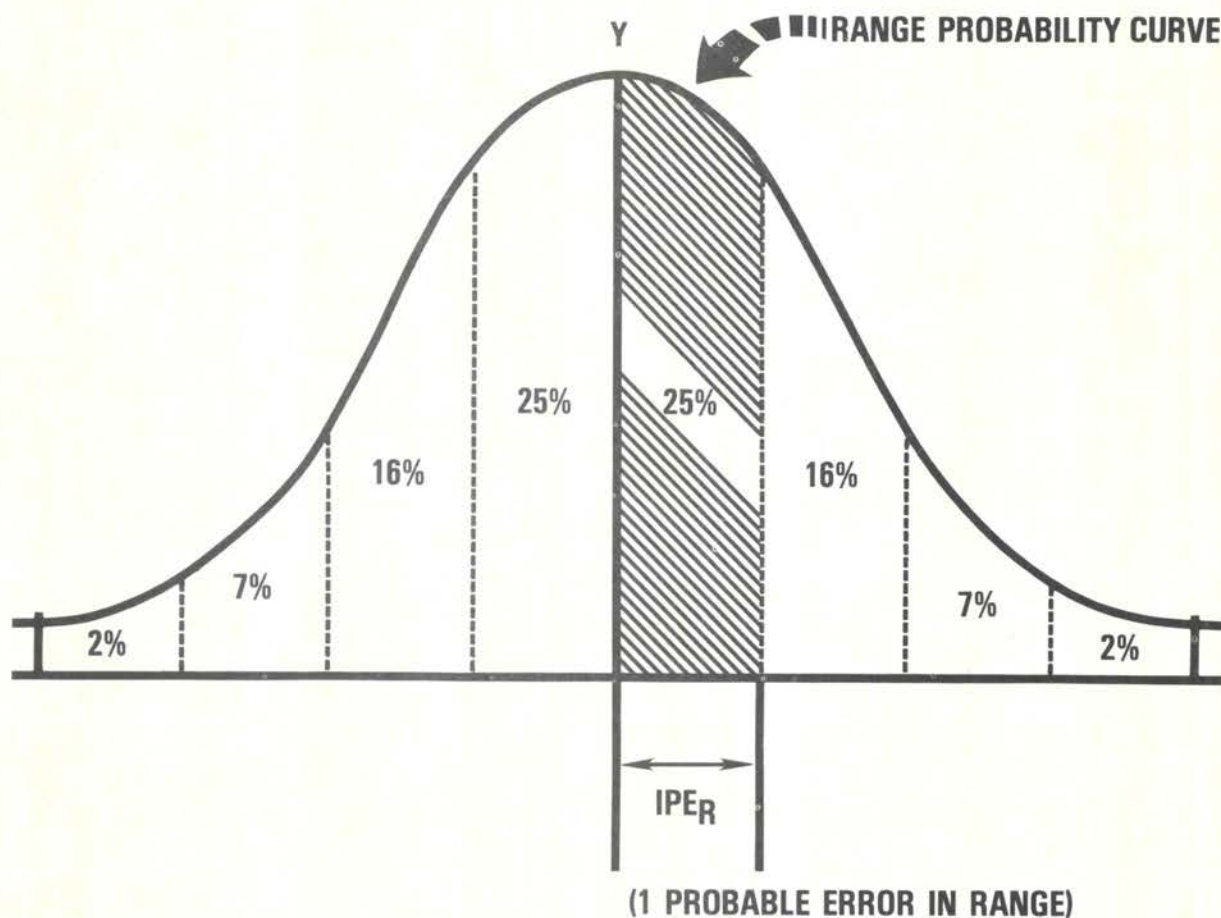


Figure B-7. Probable error.

# APPENDIX C

## TARGET ANALYSIS AND MUNITIONS EFFECTS

### C-1. Purpose

Battalion and battery fire direction officers (FDO) are responsible for the supervision of all operations within the fire direction center (FDC). The first step in processing any fire mission received in the FDC is the issuance of the FDO's fire order. The fire order is based on

the call for fire and the FDO's assessment of the target. The fire order specifies a method of attack that will place a desired effect on the target. This appendix discusses the decision procedures, manuals, and equipment used by the FDO to analyze and attack a target properly.

## Section I. TARGET ANALYSIS

### C-2. General

a. Target analysis is the examination of a potential surface target to determine:

- (1) Precedence of attack.
- (2) Most suitable attack weapon/ammunition.
- (3) Most suitable method of target attack.

b. All targets should be analyzed as they are received in the FDC and fire planning action initiated. The analysis of a target is

valid only for the level at which it was performed. For example, a battalion FDO might consider an automatic weapon an insignificant threat to the brigade mission; however, the same weapon may be of critical importance to the battery FDO of a dedicated battery supporting a maneuver platoon in contact.

c. The amount of time devoted to target analysis and the thoroughness of the analysis depends on the:

- (1) Amount of target information.



- (2) Availability of weapons to attack the target.
- (3) Urgency of engagement.

**C-3. Determining the Precedence of Attack**

*a. General.* When an FDO receives a fire mission, he is faced with the following options:

- (1) Attack the target immediately.
- (2) Defer attacking the target until an existing fire mission is complete.
- (3) Pass the fire mission to another FDC.
- (4) Cancel the mission.

An FDO selects a particular precedence of attack after considering:

- (1) Target characteristics.
- (2) Target location.
- (3) Terrain.
- (4) Weather.
- (5) Commander's criteria.

*b. Target Characteristics.*

(1) Targets encountered on the battlefield vary considerably in composition, degree of protection, shape, mobility, and

recuperability. To simplify the comparison of effectiveness of particular weapons and rounds, targets have been divided into four categories (table C-1). Several examples are listed in each category. Under certain conditions, some examples could be listed in more than one category. For example, a motorized rifle battalion could be both a category 1 and a category 4 target.

(2) For personnel targets in particular, the posture of the target is extremely important. Normally, target postures used for personnel targets are standing, prone, and foxhole. For computational purposes, it is assumed that the personnel are wearing helmets and that personnel in foxholes are in a crouching position. When describing a given target's posture, consideration must be given to the protection afforded by the terrain (e.g., an infantry platoon may be attacking in a standing posture; however, the irregularities of the terrain may provide protection equivalent to the prone position). Usually, personnel targets will seek a more protective posture during an engagement (e.g., from standing to prone position). This change is called posture sequencing. This characteristic causes considerable degradation of effects as additional volleys

Table C-1. Categories of Targets

| Categories                | Examples                                                 |
|---------------------------|----------------------------------------------------------|
| 1. Area personnel         | Squad<br>Platoon<br>Battery<br>Company                   |
| 2. Small personnel        | Observation post<br>Small patrol<br>Command post         |
| 3. Small materiel (point) | Tank<br>Armored personnel carriers<br>Bunker, machinegun |
| 4. Area materiel          | Armored Formation<br>Truck park<br>Ammo dump             |

are fired and is the reason for the continual emphasis on surprise or mass fires. For purposes of analysis, personnel targets in the offense are considered to be one-half standing and one-half prone during the first volley of fire and all prone for subsequent volleys. In a defensive configuration, personnel targets are considered to be one-half prone and one-half in foxholes during the initial volley and all in foxholes for subsequent volleys.

(3) A target must be analyzed to determine its weak points. Where the target is most vulnerable and what fires will best exploit its weaknesses are influenced by the degree of damage desired. Often there is a tendency to overkill the target when less combat power would suffice. Based on the

commander's criteria, the FDO must ascertain the degree of effects needed (destruction-neutralization-suppression) to support the tactical plan (fig C-1). The acceptable degree of damage is that level that yields a significant military advantage. For example, fire from a heavily protected machinegun emplacement may be silenced by obscuration through FA smoke and subsequent engagement by direct fire as opposed to the expenditure of an excessive number of HE rounds required for destruction.

*c. Target Location.* The proximity of the target to friendly troops and the accuracy of the target location must be weighed. The importance of certain targets that are not

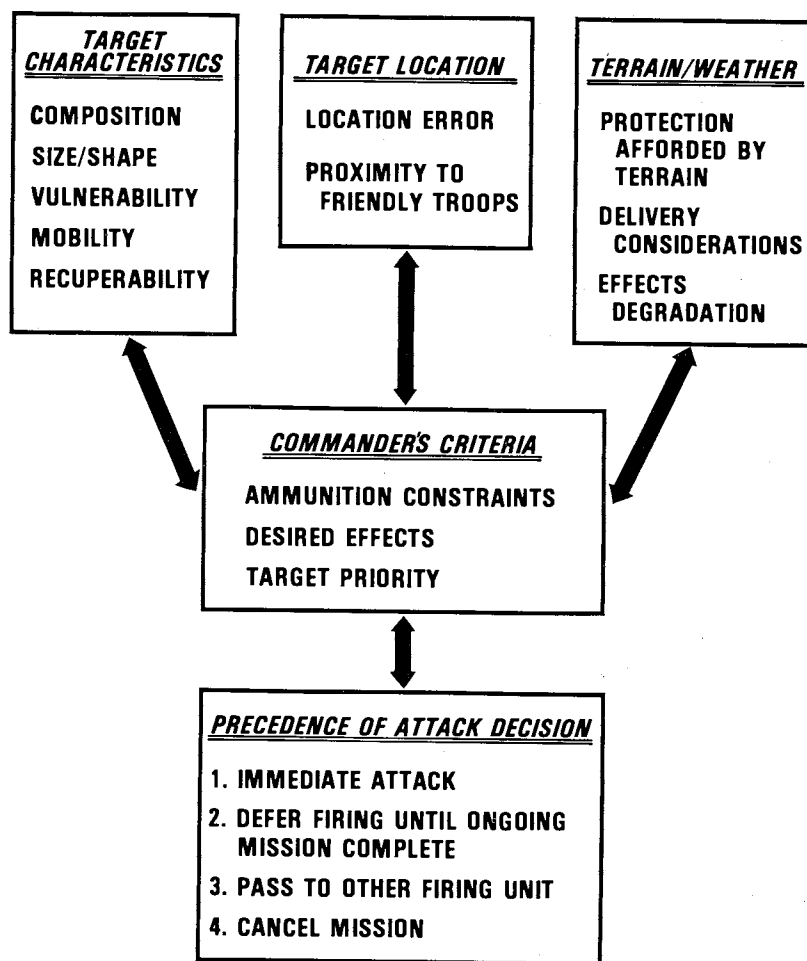


Figure C-1. Determining the precedence of attack.

accurately located may justify the fire of several units to insure coverage. Close-in direct support fire requirements may dictate the use of a specific caliber of weapon.

*d. Terrain.* The terrain in the target area has direct effect on the vulnerability of a target. Rugged terrain affords considerable natural cover and makes target location difficult. Certain terrain provides a complete defile from some angles of approach but not others, thus influencing the unit and munitions to be employed. The nature of the vegetation in the target area should be considered in the selection of ammunition.

*e. Weather.* Weather is of little consequence when evaluating a target to be attacked with HE/Q. Precipitation and wind are of particular importance in evaluating a target to be attacked with ICM, smoke, FASCAM, or illumination projectiles. Low clouds, thick fog, surface water, and rain degrade the effectiveness of VT fuze M513/M514.

*f. Commander's Criteria.* All phases of target analysis are conducted within constraints established by the commander. In determining the precedence for attacking a target, primary consideration should be given to the commander's target priorities. Based on ammunition constraints, a commander will also stipulate the type effects he desires to be attained against specific target categories. The three target effects categories are discussed below.

(1) *Suppression* of a target limits the ability of enemy personnel to perform their mission. Firing HE/VT reduces the combat effectiveness of personnel and armored targets by creating apprehension or surprise and causing tanks to button up. Smoke is used to blind or confuse. The effect of suppressive fires usually lasts only so long as the fires are continued. This type fire is used against likely, suspect, or inaccurately located enemy firing units. It can be delivered by small delivery units or means and requires a low expenditure of ammunition.

(2) *Neutralization* of a target knocks the target out of the battle temporarily. Experience has shown that 10 percent or more casualties will neutralize a unit. The unit will become effective again when the casualties are replaced and damage is repaired. Neutralization fires are delivered against targets located by accurate map inspection, by indirect fire adjustment, or by a target acquisition device. The assets required to neutralize a target vary according to the type and size of the target and the weapon/ammunition combination used.

(3) *Destruction* puts the target out of action permanently. Thirty percent casualties or materiel damage inflicted during a short time span normally renders a unit permanently ineffective. Direct hits are required to destroy hard materiel targets. Targets must be located by accurate map inspection, by indirect fire adjustment, or by a target acquisition device. Destruction usually requires large expenditures of ammunition from many units. Destruction of armored or dug-in targets with artillery weapons is not economical.

#### **C-4. Determining the Most Suitable Ammunition**

Once an FDO has decided to attack a target, he must select a weapon/ammunition combination capable of achieving a desired effect with a minimum expenditure of available ammunition stocks. Figure C-2 depicts weapon/ammunition selection considerations.

##### *a. Munitions.*

(1) *Ammunition type and quantity.* The nature of the target and its surroundings and the desired effects dictate the type and amount of ammunition to be used. For a detailed discussion of ammunition and fuzes, refer to FM 6-141-1 and FM 6-141-2. The ammunition resupply system may sometimes rule out an optimum ammunition selection. For example, extensive smoke fires may be needed to screen maneuver movement, but such fires would probably impose a considerable resupply problem on the parent

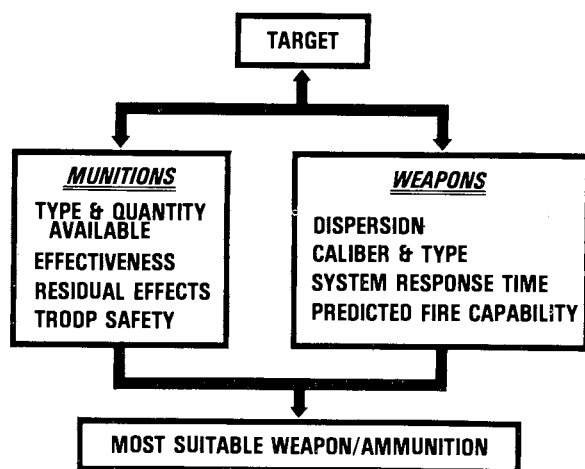


Figure C-2. Weapon/ammunition selection considerations.

organization. Some types of fires require greater ammunition expenditures than others. Suppression and neutralization fires usually consume less ammunition than destruction fires.

(2) *Troop safety.* Troop safety is a major concern when considering the weapon/ammunition selection for firing close-in targets. The FDO must insure that fires do not endanger troops, equipment, and facilities.

(3) *Residual effects in target area.* Residual effects from special ammunition will influence the occupation of an area, and FASCAM munitions may alter the direction of movement of supported elements. If supported troops are to occupy an area immediately following attack by certain munitions, conditions may be hazardous. Weather changes may alter choices of certain munitions (e.g., smoke, illumination, and special ammunition). The incendiary effects of munitions may make areas untenable for supported forces. These effects can also deny the enemy use of selected terrain.

(4) *Effectiveness.* When properly delivered against appropriate targets, artillery fire support can be the decisive factor in a battle. The FDO must insure that maximum effectiveness is attained from every mission fired. To match a munition to a target, the FDO must know what damage a

munition can produce as well as the damage required to defeat a target. The lethality of a munition must be matched to the specific vulnerability of the target. Thus the FDO must understand the damage potential of these effects from specific munitions: blast, cratering, fragmentation, incendiary, and penetration. Specific information regarding the effects of various munitions is found in the appropriate joint munitions effectiveness manual, FM 6-141-1, and FM 6-141-2. For a detailed discussion of how to predict weapon effects, refer to section II of this appendix.

#### b. Weapons.

(1) *Caliber and type available.* In certain instances, an FDO may control the fires of a dissimilar caliber reinforcing or GSR unit. The FDO must have a thorough knowledge of the characteristics, capabilities, and vulnerabilities of each weapon system. Weapons possessing slow rates of fire and poor delivery accuracy are suited for long range fires. Weapons possessing rapid rates of fire and good delivery accuracy are suited for close fires.

(2) *System response time.* An FDO must ascertain the urgency of each fire mission his FDC receives. Small and medium weapons possess a quicker firing response time than heavy weapons. Fire missions sent by the DS battalion to reinforcing or GSR units require more processing time than those sent directly to the DS units' own firing batteries.

(3) *Predicted fire capability.* The FDO must know the current survey, registration, and met status of all firing units under his control. FFE missions should be assigned to units that have the best predicted fire capability.

### C-5. Determining the Method of Attack

The final step in the FDO's target analysis is the selection of a method of attack. The FDO must select a method of attack that insures target area coverage and desired target effects. To determine an optimum method of attack, the FDO must consider aiming points,

density, and duration of fires. Figure C-3 shows the method of attack selection considerations.

*a. Aiming Points.* Normally, the size of the area to be attacked is determined by the size of the target or the size of the area in which the target is known to be located or suspected to be located. A single aiming point located on the center of the target is used to attack small targets. When attacking large targets, multiple aiming points must be designated to distribute the fires and insure adequate coverage. Chapter 12 gives procedures for establishing multiple aiming points.

*b. Density and Duration of Fires.* Intense fires of short duration generally produce the best target effect; however, the tactical situation may require fires to be continued over a long period of time. Some examples are

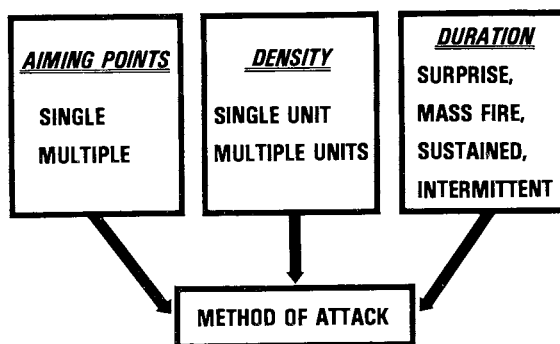


Figure C-3. Considerations in the selection of a method of attack.

harrassing and interdiction fires during darkness, screening smoke fires, continuous illumination, and suppressive fires supporting a maneuver final assault on an objective.

## Section II. PREDICTING WEAPONS EFFECTS

The most important step in performing a target analysis is determining the number and type of rounds required to produce a desired effect on a target. The battalion or battery FDO determines attack data by referring to Joint Munitions Effectiveness Manuals (JMEM), using the Graphical Munitions Effects Table (GMET), or by relying on experience.

### C-6. JMEMs

Effectiveness tables published in Joint Munitions Effectiveness Manuals for Surface-to-Surface Weapons (JMEM/SS) provide guidance for determining the expected fraction of casualties to personnel targets or damage to materiel targets. The JMEM/SSs are published as field manuals. The manuals currently available for all systems are listed in FM 6-141-1. The basic data for these manuals was obtained from test firings, actual combat performance, and

mathematical modeling. Using JMEM to determine attack data requires considerable time. Because of time constraints, the use of JMEM at battalion and battery FDC levels is not recommended for engaging targets of opportunity. The effects data included in these manuals incorporates reliability, delivery accuracy, and munitions lethality against a representative spectrum of targets. The computational assumptions, defeat criteria, and instructions for use are included in each manual. Effects are listed for the following targets and conditions:

*a. Personnel Targets.* Target radii of 50, 100, 150, 200, and 250 meters for cannon systems are given. Data for standing, prone, and foxhole postures are listed.

*b. Materiel Targets.* A short description of the following targets and their vulnerabilities is included: 150-mm rocket and launcher, FROG-4 rocket and associated launcher,

Table C-2. Available GMET

## National Stock Number Description

|                  |                                                                |
|------------------|----------------------------------------------------------------|
| 1220-01-021-7278 | (C) Scale, Graphical Munitions Effects (GMET-JMEM) f/M102(U)   |
| 1220-01-021-7279 | (C) Scale, Graphical Munitions Effects (GMET-JMEM) f/M109A1(U) |
| 1220-01-021-7276 | (C) Scale, Graphical Munitions Effects (GMET-JMEM) f/M110(U)   |
| 1220-01-021-7277 | Scale, Graphical Munitions Effects, Training (GMET-JMEM)       |

These tables are expendable items authorized by CTA 50-970.

AAA fire control radar, 152-mm field gun/howitzer, T-55 medium tank (M109A1 manual only), and ZIL-157 truck (M109A1 manual only). Additional materiel targets are added to the JMEMs as data becomes available. Thus, manuals for some systems will include more targets than those for other systems.

*c. Environment.* Open terrain, marsh grass, and temperate forest.

*d. Methods of Delivery.* Observer adjusted and met + VE.

*e. Battery Formations.* Lazy "W," star, and diamond.

*f. Ammunition.* HE, ICM, and chemical.

CAUTION: THERE IS NO ASSURANCE THAT THE EXPECTED FRACTION OF DAMAGE OR CASUALTIES WILL BE PROVIDED BY ANY NUMBER OF VOLLEYS IN A GIVEN SITUATION. ALTHOUGH NOT PRECISELY WITHIN THE MATHEMATICAL DEFINITION, THE METHOD OF AVERAGING DATA USED FOR THE TABLES WILL RESULT IN LESS DAMAGE BEING REALIZED FOR APPROXIMATELY

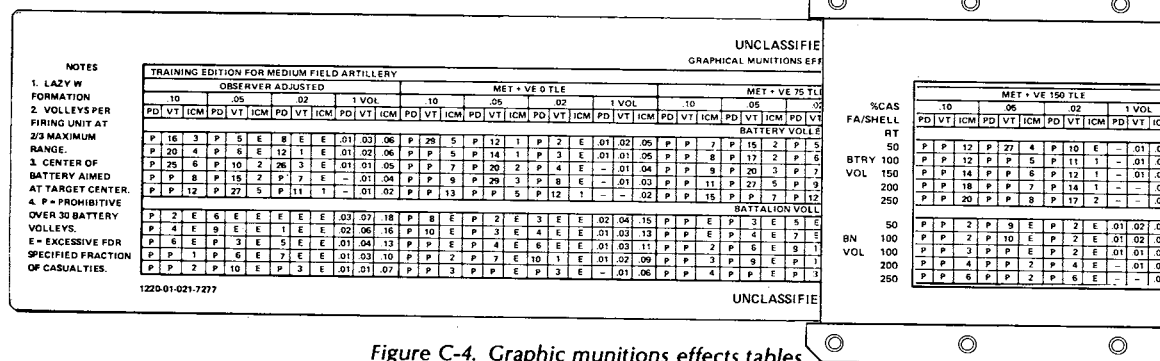
50 PERCENT OF THE ROUNDS AND CONVERSELY GREATER DAMAGE FOR THE OTHER 50 PERCENT OF THE ROUNDS.

## C-7. Graphical Munitions Effects Tables (GMET)

*a. General.* The FM 6-141 series of manuals provides doctrine for target analysis procedures and the employment of weapon systems, and the JMEMs provide excellent effectiveness data. The usefulness of these publications to the fire direction officer during field operations is limited by their volume, by the lack of accessibility, and by the difficulty of making comparisons of ammunition or weapon systems. The GMETs overcome these limitations by providing quick access to average comparative values for selected situations that the user may use as a guideline when making the engagement decision. The use of GMETs to determine target attack data is highly recommended.

(1) A complete listing of GMETs is shown in table C-2.

(2) The unclassified GMET, Training Edition for Medium Artillery (fig C-4), will generally require slightly greater expenditures than the M109A1 GMET in a given situation.



*b. Table Description.*

(1) *Composition.* The table consists of a body and plastic runner or cursor. The open or clear portion of the cursor is the window. The marginal notes provide certain assumptions for the GMET calculations.

(2) *Content.* The user can determine the number of battery or battalion volleys required to achieve a specified average expected fraction of casualties against enemy personnel in the open in either an offensive or defensive posture. The user can also determine the effects achieved with one battery or battalion volley.

(3) *Organization.* Each of the five blocks on each side of the table (e.g., observer adjusted, met + VE 0 TLE) is identical in format. Provision is made for target location error (TLE) of up to 250 meters and for three levels of effectiveness in addition to the effects of one volley.

(4) *Target size.* Data is provided for personnel targets ranging in size from 50 to 250 meters radius. The cursor is labeled with these radii of target (RT) for both battery and battalion volleys. The assumed radii for various size elements (e.g., squad 50-100 meters) are listed on the cursor. The user should consider the following additional information when using the GMET:

(a) If the dimensions of a target are less than the width of an open sheaf or a depth of 250 meters, consideration should be given to firing a converged sheaf to increase the expected fraction of casualties or decreasing the required number of volleys.

(b) If the dimensions of a target exceed the width of an open sheaf or a depth of 250 meters, consideration should be given to creating multiple targets, firing sweep and/or zone, or shifting fires.

(c) If the target is long and narrow, such as a convoy on a road, a series of 50-meter targets preceded by a multiplier to cover the length of the convoy can be used to determine the number of volleys to attack the target, provided special corrections are applied to the weapons.

(5) *Target postures.* See note 6 on the right edge of the body of the table for an

explanation of the postures used in computing weapons effects.

(6) *Percentage of casualties (% CAS).* The percentage of casualties is expressed as the average expected fraction of casualties. For example, if on one occasion the fraction of casualties is 50 percent, on another occasion, 25 percent, and on a third occasion, 25 percent, the average expected fraction of casualties would be 33 percent. There is no probability or assurance associated with the percent of casualties. Against personnel targets in an offensive posture, the assumed desired average expected fractions of casualties are 30, 20, and 10 percent. For targets in a defensive posture, the assumed casualties are 10, 05, and 02 percent. The casualty percentages for the defense are lower than for the offense because of the greater shielding of targets in a defensive posture. Shown also is the average expected fraction of casualties for one battery and one battalion volley. The number of expected casualties is the product of the average expected fraction of casualties and the number of personnel in the target area.

(7) *Shell-fuze (shell-fz) combinations.* The GMET contains effectiveness data for the standard high explosive shell (e.g., M107 for 155-mm howitzer) with point detonating (PD) or proximity (VT) fuze and the antipersonnel improved conventional munitions.

(8) *Volleys required.* The GMET lists the number of battery or battalion volleys required to achieve a specified percentage of casualties against personnel for each size target, method of delivery, shell-fuze combination, and target location error. The letter P indicates that the number of volleys required is over 30 battery or 10 battalion volleys and is considered prohibitive because any additional volleys will not achieve a significant increase in casualties. The letter E indicates that the casualties obtained would be in excess of the specified casualty level.

(9) *Met + VE delivery technique.* Effectiveness tables are based upon the average weather change that could take place using a 2-hour-old met message. Thus, when





using met data that is older than 2 hours, more volleys will be required to achieve the desired fraction of casualties. Conversely, if more accurate data is being used, fewer volleys will be required.

(10) *Observer adjusted delivery techniques.* The tables are based on the assumption that the observer has conducted sufficient adjustment to place the center of the sheaf(s) on the adjusting point (target).

*c. Other Considerations.*

(1) *Volley versus TOT fires.* The GMET assumes that battery or battalion volley fire will be used. The greatest effects are achieved when surprise fires with maximum intensity are used. Normally, the use of the time-on-target (TOT) technique will reduce the GMET expenditure for a given situation because of the reduced time the enemy has in which to seek or increase his protection.

(2) *Materiel targets (area fire).* None of the weapons are considered effective against armored targets in area fire. The probability of obtaining a hit is remote. Undoubtedly, there will be bonus effects at times, but they should be considered only as bonus effects and not be relied upon. This is not to say that exposed personnel on or adjacent to materiel targets cannot be attacked successfully with artillery.

(3) *Round-off rule.* In some instances the required expenditure for a required casualty level may appear excessive based on the one-volley effects. (See GMET Training Edition, Defensive Posture Side, MET + VE 250 TLE, 50 M RT.) The effects are calculated to four decimal places and rounded to two decimal places; thus, the one-volley effects of .02 may range from .0151 to .0250 and either one or two volleys may be required to achieve exactly .02 level of effects.

*Example:*

(A) Given:

Unit: 155-mm howitzer battalion.

Target: Platoon of infantry in the attack (assume offensive posture, radius of target 150 meters, target location error 0 meters).

Ammunition: Sufficient conventional ammunition with VT fuze is available.

Effects desired: Minimum average expected fraction of casualties of 30 percent.

(B) Procedure:

Slide the cursor to met + VE delivery technique 0 TLE on the offensive posture side of GMET. Look under the window for 30 percent casualties to see that nine battalion volleys of VT fuzed ammunition would be required to achieve 30 percent average expected fraction of casualties.

(C) Solution:

The FDO orders the battalion to fire nine volleys VT fuzed ammunition to achieve 30 percent average expected fraction of casualties.

★ C-8. Quick Reference Tables

a. If JMEMs or GMETs are not available, the FDO can use the Optimum Shell/Fuze Combination Matrix, FM 6-141-1. The table lists selected personnel and materiel targets and indicates the order of effectiveness of each shell/fuze combination. Targets not indicated should be equated to a target that is listed. The table can be used for all calibers. The use of the table is explained in the notes.

b. Expected Area of Coverage tables in FM 6-141-1 and FM 6-141-2 (C), can be used to determine the appropriate size of a battery one volley or battalion one volley of both HE and ICM for the various caliber weapon systems. The FDO can use this to determine the size target that can be attacked using battery or battalion volleys. The density of coverage is not considered, but the density of coverage of ICM is much greater than that of HE.

c. Expected Fraction of Casualties/Personnel tables in FM 6-141-1 and FM 6-141-2 (C) can be used to determine the optimum way to attack a personnel target of a 50-meter radius to achieve the commander's criteria. These tables cannot be used for materiel targets. Data is not available for the 175-mm.

## ★ APPENDIX E

## GLOSSARY

|                |                                                 |          |                                                |
|----------------|-------------------------------------------------|----------|------------------------------------------------|
| AC             | — aiming circle                                 | CLGP     | — cannon-launched guided projectile            |
| AD             | — air density                                   | CM       | — computer (met message)                       |
| ADAM           | — area denial artillery munition                | comp     | — comparative, computer                        |
| adj            | — adjust                                        | corr     | — correction                                   |
| AF             | — adjust fire                                   | CP       | — concrete piercing                            |
| alt            | — altitude                                      | CSF      | — comp site factor                             |
| AMC            | — at my command                                 | CTA      | — common table of allowance                    |
| AO             | — aerial observer                               | dE       | — difference in easting                        |
| AP             | — antipersonnel                                 | dec      | — decrease                                     |
| APC            | — armored personnel carrier                     | decl     | — declination                                  |
| APICM          | — antipersonnel improved conventional munitions | df       | — deflection                                   |
| ASR            | — ammunition supply rate                        | dft      | — drift                                        |
| AT             | — air temperature                               | dH       | — difference in height                         |
| az             | — azimuth                                       | dir      | — direction                                    |
| B              | — ballistic (met message)                       | dis      | — distance                                     |
| BC             | — battery center                                | DMD      | — digital measuring device                     |
| BCS            | — battery computer system                       | dN       | — difference in northing                       |
| BCU            | — battery computer unit                         | DP       | — dual purpose                                 |
| BMA            | — battery-minefield angle                       | DPICM    | — dual purpose improved conventional munitions |
| bn             | — battalion                                     | DS       | — direct support                               |
| BOC            | — battery operations center                     | EFC      | — equivalent full charge                       |
| BP             | — base piece, battery piece                     | el, elev | — elevation                                    |
| btry           | — battery                                       | EOM      | — end of mission                               |
| CAS, comp site | — complementary angle of site                   | ESC      | — equipment serviceability criteria            |
| CF             | — command fire                                  | ET       | — electronic time fuze                         |
| CFB            | — chief of firing battery                       | EW       | — electronic warfare                           |
| CFF            | — call for fire                                 | F        | — fallout (met message)                        |
| chg            | — charge                                        | FA       | — field artillery                              |
| cht            | — chart                                         |          |                                                |

# C1, FM 6-40

|         |                                              |          |                                     |
|---------|----------------------------------------------|----------|-------------------------------------|
| FADAC   | — field artillery digital automatic computer | L        | — left                              |
| FASCAM  | — family of scatterable mines                | LARS     | — left, add; right, subtract        |
| FD      | — fire direction                             | lat      | — latitude                          |
| FDC     | — fire direction center                      | m        | — meter                             |
| FDO     | — fire direction officer                     | mi       | — mil                               |
| FFE     | — fire for effect                            | MDP      | — meteorological datum plane        |
| FIST    | — fire support team                          | met      | — meteorological                    |
| FM      | — frequency modulated                        | MHL      | — manufacturer's hairline           |
| FO      | — forward observer                           | MPI      | — mean point of impact              |
| FPF     | — final protective fire                      | m/s      | — meters per second                 |
| FS      | — fuze setting                               | MT       | — mechanical time (fuze)            |
| FSCoord | — fire support coordinator                   | MTO      | — message to observer               |
| FSO     | — fire support officer                       | MTSQ     | — mechanical time superquick        |
| fz      | — fuze                                       | MV       | — muzzle velocity                   |
| GB      | — green bag                                  | MVV      | — muzzle velocity variation         |
| GDU     | — gun display unit                           | N        | — north                             |
| GFT     | — graphical firing table                     | NCS      | — net control station               |
| GLLD    | — ground laser locator designator            | nuc      | — nuclear                           |
| GMET    | — Graphical Munitions Effectiveness Table    | OF       | — observed fire, observed firing    |
| GS      | — general support                            | OP       | — observation post                  |
| GSR     | — general support reinforcing                | OT       | — observer-target                   |
| GST     | — graphical site table                       | PD       | — point detonating                  |
| GT      | — gun-target                                 | PEd      | — probable error in deflection      |
| G/VLLD  | — ground/vehicular laser locator designator  | PEHB     | — probable error in height of burst |
| HA      | — high angle                                 | PER      | — probable error in range           |
| HB      | — high burst                                 | pos      | — position                          |
| HCO     | — horizontal control operator                | prec reg | — precision registration            |
| HE      | — high explosive                             | proj     | — projectile                        |
| HES     | — high explosive spotting                    | prop     | — propellant                        |
| HOB     | — height of burst                            | PT       | — propellant temperature            |
| ICAO    | — International Civil Aviation Organization  | Q        | — quick                             |
| ICM     | — improved conventional munitions            | QE       | — quadrant elevation                |
| ill     | — illumination                               | R        | — right or reinforcing              |
| inc     | — increase                                   | RAAM     | — remotely activated antitank mine  |
| IR      | — infrared                                   | RAP      | — rocket-assisted projectile        |
| JMEM    | — Joint Munitions Effectiveness Manual       | RATELO   | — radio-telephone operator          |
|         |                                              | RATT     | — radioteletypewriter               |

|         |                                     |      |                                       |
|---------|-------------------------------------|------|---------------------------------------|
| RDP     | — range-deflection<br>protractor    | TFT  | — tabular firing table                |
| reg pt  | — registration point                | TGPC | — terrain gun position<br>corrections |
| rg      | — range                             | ti   | — time                                |
| S       | — south                             | TOC  | — tactical operations center          |
| SF      | — sound and flash                   | TOF  | — time of flight                      |
| si      | — site                              | TOT  | — time on target, total               |
| SITREP  | — situation report                  | UTM  | — universal transverse<br>mercator    |
| smk     | — smoke                             | VA   | — vertical angle                      |
| SOP     | — standing operating<br>procedure   | VCO  | — vertical control operator           |
| SP      | — self-propelled                    | VE   | — velocity error                      |
| SR      | — self-registration                 | VI   | — vertical interval                   |
| SW      | — southwest                         | VT   | — variable time                       |
| TACFIRE | — tactical fire direction<br>system | W    | — west, width                         |
| TAG     | — target above gun                  | WB   | — white bag                           |
| TBG     | — target below gun                  | WP   | — white phosphorus                    |
| TFC     | — total fuze correction             | wt   | — weight                              |
|         |                                     | XO   | — executive officer                   |

★ APPENDIX F

*ARTILLERY FIRE  
DIRECTION CENTER  
STANDARDIZATION*

(To be published)

# APPENDIX G

## INTERNATIONAL STANDARDIZATION AGREEMENTS

Standardization agreements (STANAGs and QSTAGs) are international agreements designed to facilitate allied operations. Upon ratification by the United States, these standardization agreements are binding upon the United States Forces (entirely or with exceptions as noted).

### G-1. STANAGs

A STANAG is an international agreement wherein the nations of a specific treaty organization, such as NATO, SEATO, or CENTO, agree to certain operational actions to enhance the allied operation. The status of STANAGs associated with field artillery cannon gunnery, which the United States agrees to implement and promulgate, are categorized as in table G-1.

### G-2. QSTAGs

A QSTAG is an international agreement wherein the ABCA nations (United States, United Kingdom, Canada, Australia) form a quadripartite alliance and agree to certain

operational and procedural techniques to enhance the allied operation. Status of QSTAGs associated with field artillery cannon gunnery, which the United States agrees to implement and promulgate, are categorized in table G-2.

### G-3. Implementation

The doctrine, procedures, and techniques promulgated in the above STANAGs and QSTAGs are implemented in this manual only as indicated in the STATUS shown for each STANAG/QSTAG. As ratification details occur, specifically those agreements that have been changed by USAFAS, subsequent implementation and promulgation action will be made accordingly. Paragraphs G-4 through G-7 are examples of basic cannon gunnery procedures as promulgated in the various QSTAGs and STANAGs and are included here to allow member nation units to operate with United States Army units when this manual is the only reference available.

Table G-1. STANAG International Agreements

| STANAG | SUBJECT                                                               | STATUS                                                                         |
|--------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 2144   | Call for Fire Procedures                                              | USAFAS changes to US-ratified STANAG 2144 are included in this manual.         |
| 2867   | Radio-Telephone Procedures for the Conduct of Artillery Fire          | USAFAS changes to US-ratified STANAG 2867 are included in this manual.         |
| 2875   | Calls for Destruction, Smoke, Illumination, and Danger Close Missions | USAFAS changes to nonratified (DRAFT) STANAG 2875 are included in this manual. |

Table G-2. QSTAG International Agreements

| QSTAG | SUBJECT                                                                                                                        | STATUS                                                               |
|-------|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| 220   | Cannon Artillery Equipment and Procedures for the Manual Determination of Firing Data for Nonstandard Conditions for Post-1970 | ABCA-ratified. Amendment action is ongoing.                          |
| 224   | Manual Fire Direction Equipment, Target Classification and Methods of Engagement for Post-1970                                 | ABCA-ratified.                                                       |
| 225   | Call for Fire Procedures                                                                                                       | USAFAS changes to US-ratified QSTAG 225 are included in this manual. |
| 246   | Radio-Telephone Procedures for the Conduct of Artillery Fire                                                                   | USAFAS changes to US-ratified QSTAG 246 are included in this manual. |

**G-4. Call for Fire Other Than US (Example)**

| Serial | General Heading                                                | Specific Example                                 |
|--------|----------------------------------------------------------------|--------------------------------------------------|
| 1      | OBSERVER'S IDENTIFICATION                                      | 20, THIS IS 21                                   |
| 2      | WARNING ORDER                                                  | FIRE MISSION BATTERY                             |
| 3      | LOCATION OF TARGET INCLUDING DIRECTION                         | GRID 123456<br>ALTITUDE 100<br>DIRECTION 1640    |
| 4      | TARGET DESCRIPTION                                             | PLATOON DUG IN ON RIDGE<br>200x50, ATTITUDE 4850 |
| 5      | METHOD OF ENGAGEMENT<br>a. TYPE OF ENGAGEMENT<br>b. TRAJECTORY | DANGER CLOSE<br>HIGH ANGLE                       |

- c. AMMUNITION  
d. DISTRIBUTION OF FIRE
- 6 METHOD OF FIRE AND CONTROL

VT IN EFFECT 10 ROUNDS  
OPEN

AT MY COMMAND  
TWO GUNS PLATOON RIGHT  
ADJUST FIRE

#### G-5. US Call for Fire (Example)

| Serial | General Heading            | Specific Example                                 |
|--------|----------------------------|--------------------------------------------------|
| 1      | OBSERVER'S IDENTIFICATION  | A57, THIS IS A71                                 |
| 2      | WARNING ORDER              | ADJUST FIRE, SHIFT 176                           |
| 3      | LOCATION OF TARGET         | DIRECTION 5210, LEFT 380, ADD 400,<br>DOWN 25    |
| 4      | TARGET DESCRIPTION         | PLATOON DUG IN ON RIDGE<br>200x50, ATTITUDE 4850 |
| 5      | METHOD OF ENGAGEMENT       |                                                  |
|        | a. TYPE OF ENGAGEMENT      | DANGER CLOSE                                     |
|        | b. TRAJECTORY              | HIGH ANGLE                                       |
|        | c. AMMUNITION              | VT IN EFFECT 10 ROUNDS*                          |
|        | d. DISTRIBUTION OF FIRE    | OPEN                                             |
| 6      | METHOD OF FIRE AND CONTROL | TWO GUNS<br>AT MY COMMAND                        |

\*US OBSERVER WILL NOT SPECIFY NUMBER OF ROUNDS.

#### G-6. An Area Target Engaged by a Battery of US Artillery When the Observer is From Another Member Nation (Example)

| Serial | Observer's Request                             | Reports to Observer                         |
|--------|------------------------------------------------|---------------------------------------------|
| 1      | OBSERVER'S IDENTIFICATION                      |                                             |
| 2      | FIRE MISSION                                   |                                             |
| 3      | GRID 321456, ALTITUDE 120                      |                                             |
| 4      | DIRECTION 5100                                 |                                             |
| 5      | VEHICLE PARKED IN WOODS 200x100, ATTITUDE 2850 |                                             |
| 6      | ADJUST FIRE                                    |                                             |
| 7      |                                                | BATTERY IDENTIFICATION,<br>6 ROUNDS ZP 7115 |



|    |                                           |                 |
|----|-------------------------------------------|-----------------|
| 8  |                                           | SHOT            |
| 9  | RIGHT 100, ADD 400                        |                 |
| 10 |                                           | SHOT            |
| 11 | DROP 200                                  |                 |
| 12 |                                           | SHOT            |
| 13 | DROP 100                                  |                 |
| 14 |                                           | SHOT            |
| 15 | DROP 50, FFE                              |                 |
| 16 |                                           | SHOT            |
| 17 |                                           | ROUNDS COMPLETE |
| 18 | END OF MISSION. THREE<br>VEHICLES BURNING |                 |

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| 2      | ADJUST FIRE                                            |                                    |
| 3      | GRID 321456                                            |                                    |
| 4      | SIX ARMORED PERSONNEL<br>CARRIERS                      |                                    |
| 5      |                                                        | BATTERY IDENTIFICATION<br>6 ROUNDS |
| 6      |                                                        | SHOT                               |
| 7      | DIR 1680, R120, ADD 400                                |                                    |
| 8      |                                                        | SHOT                               |
| 9      | DROP 200                                               |                                    |
| 10     |                                                        | SHOT                               |
| 11     | DROP 100                                               |                                    |
| 12     |                                                        | SHOT                               |
| 13     | ADD 50, FFE                                            |                                    |
| 14     |                                                        | SHOT<br>ROUNDS COMPLETE            |
| 15     | END OF MISSION.<br>TWO PERSONNEL<br>CARRIERS DESTROYED |                                    |

## APPENDIX H

# EMPLOYMENT OF ARMOR IN A FIELD ARTILLERY ROLE

### Section I. INTRODUCTION

#### H-1. Purpose

Although tanks are traditionally a direct fire weapon, under exceptional circumstances, the force commander may decide to employ tanks in an indirect fire role. The tank unit may be attached to the field artillery unit or it may be given a reinforcing role. This appendix discusses the gunnery techniques to be used and other factors to be considered by the field artilleryman, when the tank unit is under field artillery control.

#### H-2. General

a. Because of the small bursting radius of the high-velocity, flat-trajectory ammunition and the short tube life of the tank gun, tank guns normally are not used in the field artillery (indirect fire) role.

b. When the tank unit is attached to or reinforcing a field artillery unit, the field artillery unit is responsible for fire control, communications, and survey. If the tank unit is attached, the field artillery unit is also

responsible for ammunition, fuel, rations, and other supplies.

c. Whether attached or reinforcing, the tank unit must retain the capability of reverting immediately to its primary role; therefore, its basic load of ammunition should not be used in the indirect fire role. If possible, ammunition should be prestocked for this purpose.

d. For information on the mission and tactical employment of tank units, on the characteristics of tanks and tank fire control equipment, and on direct fire with tank weapons, see the 17- and 71-series field manuals.

e. The normal width of a tank platoon front in the position area is about 150 meters. For tanks, a parallel sheaf produces an effective pattern of bursts with this position area width. For position areas of different widths, it is necessary to adjust the width of sheaf in order to obtain the most effective pattern of bursts.

**H-3. Ammunition**

HEP and WP projectiles are available for the 105-mm tank guns (M60, M60A1, M48A5, and XM1 tanks). Separate fuzes are not available;

all projectiles are fixed with point detonation fuzes.

*Note.* See TM 43-0001-28 for further information on ammunition.

## Section II. FIRE CONTROL PROCEDURES

**H-4. Observer Procedures**

Field artillery observer procedures are used in conducting indirect fire with tanks.

**H-5. Fire Direction**

*a. Firing Chart.* The location of each tank platoon is plotted on the field artillery firing chart. A deflection index is constructed at zero deflection by orienting the left edge of the arm of the range-deflection protractor (RDP) in the direction on which the tanks are laid and drawing the index on the chart at the center graduation of the mil scale on the arc. The RDP is numbered for reading shifts of 500 mils right or left of the direction of lay as follows:

(1) Number the center graduation 0.

(2) Number each succeeding 100-mil graduation to the right "L1" through "L4" and each succeeding graduation to the left "R1" through "R4." The last graduation on each end need not be numbered. For reading shifts greater than 500 mils, additional indexes must be constructed. If tank weapon firing tables are not available to the fire direction center, the tank unit usually fires only observed fires in the indirect role. If tabular firing tables are available, a registration should be conducted and corrections applied. Corrections sent by the observer during adjustment are plotted using the target grid as outlined in chapter 3, and the armor fire control officer (FCO) will compute a range K for his weapons.

*b. Fire Commands.*

(1) Fire command information is sent from the fire direction center to the tank unit fire control officer, who is the tank platoon commander and is responsible for tank fire. The FCO converts this information to a platoon fire command and sends it to the tanks. The FCO requires the range from the platoon target, the difference in altitude, the direction, and target description.

(a) The range information is given to the nearest 100 meters.

(b) When the target is at a different altitude from that of the tank, an angle of site is computed in mils and is included in the fire commands. The complementary angle of site for high-velocity guns is negligible and is ignored.

(c) The direction information is given in terms of a reference point. In the indirect fire role, the tanks are laid on an azimuth, and this azimuth is considered the reference point. When the tank is laid, the azimuth indicator is zeroed, and directions are given as right or left of the reference point. Aiming posts may be set out and alined on a common deflection, usually at zero, or 2600 or 2800 mils to the right front. Since the tank does not have a panoramic sight, the aiming post deflection is merely an offset angle. During lulls in the firing, the gunner checks a tank's displacement by using the aiming posts without traversing the turret (tube) back to the aiming circle.

(d) The nature of the target is announced to the tanks as a portion of their fire command.

(2) Once the fire control officer has the firing information of range, altitude, direction, and target description, he must convert this data so that a fire command can be sent to the tanks.

(a) The range information must be received as a quadrant reading, which includes angle of site and the elevation corresponding to the range.

(b) The direction command must be modified so that it can be placed on the tank's instruments.

(c) An example of a platoon fire command issued by the fire control officer is shown below:

|                     |
|---------------------|
| PLATOON             |
| HEP                 |
| MORTARS FIRING      |
| 3127 RIGHT          |
| QUADRANT +430       |
| AT MY COMMAND, FIRE |

1. *Platoon.* The normal method of employing tanks in an indirect fire role is by platoon (five tank guns). To alert all fire weapons that they will fire, the command is PLATOON. To alert all pieces to follow with one tank firing in adjustment, the command is PLATOON ADJUST, NUMBER THREE (the number three piece firing in adjustment).

2. *HEP.* The ammunition command is similar to that for field artillery except that the word "shell" is omitted.

3. *Mortars firing.* The nature of the target is announced to the tank unit as a portion of the fire command.

4. *Deflection 3127 right.* This portion of the fire command is the direction and must be computed by the FCO using the direction information sent from the FDC and drift data contained in tank firing tables. Once the direction of the gun has been computed, and drift accounted for, it must be converted to a reading that can be applied to the tank azimuth indicator. The tank azimuth indicator is numbered left from zero to 3200

mils and from that point again from zero to 3200 mils. Because of this, a direction and an azimuth to the left of the reference point are the same, but to the right the two numbers are different and always sum up to 3200. A direction RIGHT or LEFT must be included in the command since this determines which direction along an axis the tubes point.

5. *Quadrant + 430.* The FCO obtains the superelevation angle from the firing tables and combines it with the angle of site announced by the FDC. The tank weapons may be laid for elevation by using either the gunner's quadrant or the elevation quadrant. Since the range of most tank weapons is limited by the inability to elevate to high angles, it may be necessary either to dig in the rear of the tanks or to place the tanks on a ramp that slopes away from the direction of fire.

6. *At my command, fire.* The command AT MY COMMAND tells the tank crew to notify the FCO when it is ready to fire. The command to open fire is FIRE. In tank gunnery, this command is the last element in the sequence of fire command because the tank gunner is trained to hold his fire until the command FIRE is received.

*Note.* When required, other fire commands used by the artillery (e.g., pieces to fire, method of fire) are sent to the tanks in the simplest and most understandable manner. Common sense and liaison between artillery and armor should overcome difficulties caused by lack of formal procedure. This problem is further alleviated through the use of prearranged data sheets.

## H-6. Alternate Methods

Other methods that may be employed in controlling the indirect fire of tanks are as follows:

a. *Independent Method.* The tank unit uses fire direction equipment and personnel organic to the tank battalion to form, with artillery assistance, a fire direction center.

b. *Semi-Independent Method.* The tank unit handles its own indirect fire missions from prearranged data sheets. Survey control, meteorological computations,

prearranged data sheets, and assistance in laying the tanks may be provided by the supported artillery. Interdiction and harassing missions are the types of missions handled most effectively by use of data sheets.

## ★ APPENDIX I

# INTERCHANGEABILITY OF AMMUNITION

During combined operations, it may be necessary to use ammunition held in stock by other NATO nations. To facilitate this interoperability, FM 6-50, appendix I, lists those projectiles, fuzes, and propellants that are authorized and acceptable for exchange between US and various allied nations.

The firing tables and fire control information to be used to fire foreign ammunition currently in stock are provided in table I-1. In the case of the German propellant charges, only a muzzle velocity correction should be applied.

Table I-1. Firing Tables and Fire Control Information to be Used by US With Foreign Ammunition

| CALIBER         | WEAPON | MANUAL                    | FADAC                 | TACFIRE                |
|-----------------|--------|---------------------------|-----------------------|------------------------|
| 105-mm          | M101   | FT 105-H-7                | FCIF 105-H-A          | FCI 105-H-A            |
|                 | M101A1 | w C1, 3, 4                | w C1                  | w C1, 2, 3, 4          |
|                 | M102   | FT 105-AS-2               | FCIF 105-AS-A         | FCI 105-AS-A           |
|                 | M108   | w C3, 5, 6, 7, 8          | w C1                  | w C1, 2, 3             |
| 155-mm          | M114   | FT 155-Q-4                | FCIF 155-Q-A          | FCI 155-Q-A            |
|                 | M114A1 | w C2, 3, 4                | S-2 w C1              | S-2 w C1               |
|                 |        | No US table               | No US table           | No US table            |
|                 | M114A2 | FT 155-AH-3               | FCIF 155-AH-B         | FCI 155-AH-B           |
|                 | M109   | w C2, 3, 4, 5             | w C1, 2               | w C1, 2                |
|                 | M109A1 | FT 155-AM-1               | FCIF 155-AM-A         | FCI 155-AM-A           |
|                 | M109A2 | w C1, 3, 4, 5             | w C1                  | w C1                   |
|                 | M109A3 |                           |                       |                        |
|                 | M198   |                           |                       |                        |
| 175-mm          | M107   | FT 175-A-1<br>w C1        | FCIF M5-A-A<br>w C1   | FCI 175-A-A<br>w C1, 2 |
| 8-inch (203-mm) | M110   | FT 8-J-4<br>w C1, 2       | FCIF 8-J-A<br>w C1    | FCI 8-J-A<br>w C1, 2   |
|                 | M110A2 | FT 8-Q-1<br>w C1, 2, 3, 4 | FCIF 8-Q-A<br>w C1, 2 | FCI 8-Q-A<br>w C1      |

# ★ *APPENDIX J*

# *REFERENCES*

## **J-1. Publication Indexes**

Department of the Army Pamphlets of the 310-series should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to material covered in this manual.

## **J-2. Army Regulations (AR)**

- |        |                                            |
|--------|--------------------------------------------|
| 310-25 | Dictionary of United States Army Terms     |
| 310-50 | Authorized Abbreviations and Brevity Codes |

## **J-3. Department of Army Field Manuals (FM)**

- |              |                                                                         |
|--------------|-------------------------------------------------------------------------|
| 3-10         | Employment of Chemical Agents                                           |
| 6-2          | Field Artillery Survey                                                  |
| 6-15         | Field Artillery Meteorology                                             |
| 6-20         | Fire Support in Combined Arms Operations                                |
| 6-20-1       | Field Artillery Cannon Battalion                                        |
| 6-30         | The Field Artillery Observer                                            |
| 6-40-3       | Operation of the Gun Direction Computer M18, Cannon Gunnery Application |
| 6-50         | The Field Artillery Cannon Battery                                      |
| 6-121        | Field Artillery Target Acquisition                                      |
| 6-141-1      | Field Artillery Target Analysis and Weapons Employment: Nonnuclear      |
| (C) 6-141-2  | Field Artillery Target Analysis and Weapons Employment: Nuclear (U)     |
| 6-300        | Army Ephemeris, 1980                                                    |
| 21-6         | How to Prepare and Conduct Military Training                            |
| 21-26        | Map Reading                                                             |
| 23-90        | 81-mm Mortar                                                            |
| 23-91        | Mortar Gunnery                                                          |
| 23-92        | 4.2-Inch Mortar, M30                                                    |
| (C)101-60-17 | Basic Effectiveness Manual, Surface-to-Surface (U)                      |

## **C1, FM 6-40**

### **J-4. Firing Tables (FT)**

|             |                                                                                                                                                                                                                                                                                                                                              |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8-R-1       | Cannon, 8-Inch Howitzer M201, on Howitzer, Heavy, Self-Propelled, 8-Inch, M110A1, and Cannon, 8-Inch Howitzer, M201A1 on Howitzer, Heavy, Self-Propelled, 8-Inch, M110A2, Firing Projectile, HES M424 and M424A1, and Projectile, Atomic, M422A1                                                                                             |
| 14.5-A-1    | Cannon, 14.5-mm, M31, Artillery Trainer Firing Fuzed Cartridges, M181, M182 and M183                                                                                                                                                                                                                                                         |
| 155 ADD-I-1 | Addendum to FT 155-AM-1 for Projectile, HE, M449A1 (M449E2), M449 (T379), and M449E1                                                                                                                                                                                                                                                         |
| 155 ADD-J-1 | Addendum to FT 155-AN-1 for Projectile HE M483A1                                                                                                                                                                                                                                                                                             |
| 155 ADD-L-1 | Addendum to FT 155-AN-1 for Projectile, HE, M692 and Projectile, HE, M731                                                                                                                                                                                                                                                                    |
| 155 ADD-N-1 | Addendum to FT 155-AN-1 for Projectile, Antitank, M718/M741                                                                                                                                                                                                                                                                                  |
| 155-AJ-2    | Cannon, 155-mm Howitzer, M126A1 and M126 on Howitzer, Medium, Self-Propelled, 155-mm, M109 and Cannon, 155-mm Howitzer, M185 on Howitzer, Medium, Self-Propelled, 155-mm M109A1, Firing Projectile, Atomic, M454                                                                                                                             |
| 155-AM-1    | Cannon, 155-mm Howitzer: M185 on Howitzer, Medium, Self-Propelled: 155-mm, M109A1 and M109A2; Firing Projectile, Smoke, BE: M116 and M116B1 (HC and Colored); Projectile, Gas Persistent, H and HD: M110; Projectile, Gas, Nonpersistent, GB: M121A1; Projectile, Gas, Persistent VX: M121A1 and Projectile, Illuminating: M485A2 and M485A1 |
| 155-AN-1    | Cannon, 155-mm Howitzer, M185 on Howitzer, Medium, Self-Propelled, 155-mm, M109A1, and Howitzer, Medium, Self-Propelled, 155-mm, M109A1B Firing Projectile HE M483A1                                                                                                                                                                         |

### **J-5. Training Circulars (TC)**

|        |                                   |
|--------|-----------------------------------|
| 21-5-3 | TEC Management Instruction        |
| 21-5-7 | Training Management in Battalions |

### **J-6. DA Forms (available through normal AG publications supply channels)**

|        |                                                     |
|--------|-----------------------------------------------------|
| 2408-4 | Weapon Record Data                                  |
| 3675   | Ballistic Met Message                               |
| 3677   | Computer Met Message                                |
| 4176   | Target Grid, Scale 1:25,000 Meters                  |
| 4200   | Met Data Correction Sheet                           |
| 4201   | High Burst (Mean Point of Impact) Registration      |
| 4207   | 8-Inch Nuclear Computation—MET Plus VE              |
| 4504   | Record of Fire                                      |
| 4505   | 155-mm Nuclear Computation—MET Correction Technique |



|          |                                             |
|----------|---------------------------------------------|
| 4757     | Registration/Special Correction Worksheet   |
| 4758     | Section Chief Card, Computation Worksheet   |
| ★ 4982   | Muzzle Velocity Record                      |
| ★ 4982-1 | M90 Radar Chronograph/Velocimeter Worksheet |

**J-7. Technical Manuals (TM)**

|                  |                                                                                                                                                                                        |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5-241-2          | Universal Transverse Mercator Grid, Zone-to-Zone Transformation Tables                                                                                                                 |
| 6-230            | Logarithmic and Mathematical Tables                                                                                                                                                    |
| 9-1220-221-10/1  | Operator's Manual: Computer Gun Direction, M18                                                                                                                                         |
| *9-1220-242-12&P | Operators and Organizational Maintenance Manual, Computer Set, Field Artillery, General, and Computer Set, Field Artillery, Missile                                                    |
| 9-6920-361-13&P  | Operator, Organizational and Direct Support Maintenance Manual (Including Repair Parts and Special Tools List): Field Artillery Trainer Kits (With Field Artillery Trainer M31)        |
| 38-750           | The Army Maintenance Management System (TAMMS)                                                                                                                                         |
| 43-0001-28       | Army Ammunition Data Sheets for Artillery Ammunition: Guns, Howitzers, Mortars, Recoiless Rifles, Grenade Launchers, and Artillery Fuzes (Federal Supply Class 1310, 1315, 1320, 1390) |

\*To be published

**J-8. Miscellaneous Publications**

|             |                                                                                                                                |
|-------------|--------------------------------------------------------------------------------------------------------------------------------|
| ARTEP 6-105 | Field Artillery 105-mm Self-Propelled Support Cannon Units                                                                     |
| ARTEP 6-165 | General Support Cannon Units                                                                                                   |
| ARTEP 6-365 | Field Artillery, 155-mm, SP, Direct Support Cannon Units                                                                       |
| ARTEP 7-15  | Infantry Battalions (Infantry, Airborne, Air Assault and Ranger)                                                               |
| ARTEP 71-2  | Mechanized Infantry/Tank Task Force                                                                                            |
| QSTAG 220   | Cannon Artillery Equipment and Procedures for the Manual Determination of Firing Data for Nonstandard Conditions for Post 1970 |
| QSTAG 224   | Manual Fire Direction Equipment, Target Classification and Methods of Engagement for Post 1970                                 |
| QSTAG 225   | Call for Fire Formats                                                                                                          |
| QSTAG 246   | Radio-Telephone Procedures for the Conduct of Artillery Fire                                                                   |

**J-9. USAFAS Training Support Publications**

Field Artillery Catalog of Instructional Material (available by writing: Commandant, USAFAS, ATTN: ATSF-CR-TS, Fort Sill, OK 73503).

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